SCIENCE ABSTRACTS.

PHYSICS AND ELECTRICAL ENGINEERING.

FEBRUARY 1902.

GENERAL PHYSICS.

266. *Dial Slide-Rule.* **P. Weiss.** (Soc. Franç. Phys., Séances, 2. pp. 77–79, 1901.)—The instrument, which is constructed by I. Werlein, is to facilitate multiplication and division. It consists of a dial with a logarithmic graduation on its circumference, and two pointers, the indicator and the multiplier; the latter can be moved independently, but takes part in all the movements of the former. H. B.

267. *Manipulation of Liquefied Gases in Sealed Tubes.* **H. Moissan.** (Comptes Rendus, 188. pp. 768–771, Nov. 11, 1901.)—The author investigates the temperatures produced by the evaporation of solutions of solid carbon dioxide in various liquids. Acetone was found to be the most suitable, and with this solvent the temperature fell to −98° C. When dry air, previously cooled to −80° C., was led into the mixture, the temperature was −110° C. If it is desired to examine the action of a liquefied gas on a solid substance in a sealed tube, the temperature should be lowered until the gas solidifies, when the tube may be exhausted and easily sealed. Glass tubes of 1·5 mm. interior and 6 mm. exterior diameter will withstand pressures of over 800 atmospheres.

In order to examine the products obtained, the tube should be cooled down again until the gas solidifies, and the point then broken off. By connecting with a pump, and gradually allowing the temperature to rise, the products may be fractionally distilled. Certain precautions must be taken; in particular the gases should be pure, and no trace of moisture must be present. When hydrogen is evolved the method is useless, as the tubes burst; if the tubes are cooled below −200° C. they generally break on attaining the ordinary temperature. W. C. B.

268. *Viscosity of Sulphur.* **C. Malus.** (Annal. Chim. Phys. 7. pp. 491–574, Dec., 1901.)—The author died during this research. This account was compiled by Duhem after the author's notes. The sulphur was crystallised from carbon disulphide, dried and pressed for months, ground and fused in glass tubes, afterwards sealed. The paper does not confine itself to the viscosity [see Abstract No. 1778 (1900)]. Ordinary sulphur, S_1, contains gaseous SO_2. This gas can be expelled by heating the sulphur for several hours above 800° C., or at 185° C., by sending a current of CO_2 through the liquid. The sulphur, S_1, has then passed into S_2, which is reconverted into S_1 when heated in the presence of SO_2. The two modifications differ in colour, viscosity, &c. When heated to 357° C. for fifteen minutes only and then cooled to 100° C., S_1 passes into the third modification S', which still retains the SO_2, and can be reconverted into S_1. When sulphur is fused at 120° C. in a partial vacuum, solidified, and remelted, the resulting liquid column is full of gas bubbles which can be removed by shaking; but on repeating this experiment eighty times, when the tube broke, the author still observed the formation of gas bubbles. H. B.

269. *Hydrostatic Pressure.* **W. Ramsay.** (Archives Néerlandaises, 6. pp. 349–351, 1901.)—The paper describes an attempt made to determine whether fine-grained particles, having incessant pedetic motion in a liquid, exert hydrostatic pressure. The density of a colloidal solution of arsenious sulphide in water is determined, first by a hydrostatic method, and then by the pyknometer. The same is done for barium chloride. In both cases the pyknometer is found to give a higher value, but the difference is so small as to be comparable with the errors of observation. The author concludes that the particles by their impacts on the sinker exert hydrostatic pressure. J. W. P.

270. *Equations of Flow of Fluids.* **D. J. Korteweg.** (Archives Néerlandaises, 6. pp. 1–24, 1901.)—The necessary modification of the equations of motion of a compressible viscous fluid, when account is taken of the capillary forces due to considerable but continuous variations of density, is here considered, and the theory of capillarity on the hypothesis of a continuous variation of density is discussed. The memoir is too mathematical to be abstracted. R. E. B.

271. *Small Elastic Displacements.* **F. Kohlrausch** and **E. Grüneisen.** (Preuss. Akad. Wiss. Berlin, Sitz. Ber. 46. pp. 1086–1091, Nov. 14, 1901.)—Reference to the work of Bach is made, in which the connection between stress and strain is expressed by the formula $\epsilon = A\sigma^m$, where ϵ is the relative extension or contraction, σ the force per unit area, and A and m are constants of the material. This law, or a similar one with a series of powers, is said to express the connection of stress and strain more accurately than the old law of simple proportion. The importance of such a formula for technical purposes is admitted, but the theoretical importance claimed by Bach is doubted. The validity of extending the supposition at all beyond the experimental range is denied, and the need for investigation, especially in the low values, is insisted upon. Experiments by the authors upon the flexure of rods of cast iron, wrought iron, brass, and slate are given. In these an optical method is used, and the strains are measured with great exactitude. For wrought iron the law of simple proportion is found to hold. A less complete adherence to this was found in the case of brass, but the deviation was much less than that found by Bach. Slate, within the limits experimented upon, acted as a completely elastic body, and showed an unexpectedly high elasticity modulus. For grey cast iron, agreement with Bach's results is found. The formula $y/x = A + B\sqrt{x}$, where x and y are the stress and strain, A and B elastic constants, is suggested as satisfying the results more closely than Bach's formula. The question of discontinuity in the passage from extension to compression is also touched upon. J. W. P.

272. *On the Maximum Dynamical Stress in Elastic Systems.* **T. Levi-Civita.** (N. Cimento, 2. pp. 188–196, Sept., 1901.)—This memoir begins with a reference to Beltrami's law that the true measure of the force to which the molecular cohesion can be subjected at every point of an elastic body is the value assumed at the point by the potential of the elastic forces. This superior limit is denoted in the present paper by P_d, and the writer proposes to prove that—

$$P_d = 2P_s + E + 2\sqrt{P_s(P_s + E)},$$

where E is the total energy of the body in its initial state, and P_s is defined as follows: If π denote the elastic potential, and $P = -\int \pi ds$, taken throughout the body, then P_s is the value of P corresponding to the position of static equilibrium under the action of the given forces. If U denote the work done by the external forces on displacements denoted at every point by u, v, w, and T be the kinetic energy, $E = T_0 + P_0 - U_0$, and the general equations of the theory of elasticity lead to the equation—

$$T + P - U = E, \dots\dots\dots\dots \quad (3)$$

the external forces being supposed independent of the time. The author next considers the superior limit of P for the case in which (3) is the only equation. This limit is called P', and the author says that evidently $P_d \leqq P'$. The value of P' is found by reducing to zero the variation of P, given $T + P - U = E$, according to the usual method, writing—

$$\delta P + \lambda T(T + P - U) = 0.$$

Writing μ for $\lambda/(1 + \lambda)$, this leads to the equation—

$$\mu^2 - 2\mu P_s = E\,;$$

whence—

$$\mu = 1 \pm \sqrt{1 + E / P_s}.$$

The roots must be real. The superior limit sought is found by taking the positive sign, or $\mu = 1 + (1 + E/P_s)^{\frac{1}{2}}$. The author then finds the result proposed, viz.—

$$P' = \mu^2 P_s = 2P_s + E + 2\{P_s(P_s + E)\}^{\frac{1}{2}}.$$

He further concludes that the displacements u', v', w', for which $P = P_d$, the maximum dynamical stress, are in general uniquely determined, and proportional to u_s, v_s, w_s, those of the statical stress, namely—

$$u' = W_s\{1 + (1 + E/P_s)^{\frac{1}{2}}\}, \text{ \&c.}$$

The only case excluded is that in which no external forces act, there being then an infinite number of sets of displacements which give to P its maximum value E. Two examples are given. S. H. B.

273. *Temporary Set in Wires.* **C. Barus.** (Phys. Rev. 13. pp. 283–306, Nov., 1901.)—From Kelvin's work we know that mechanical strain is accompanied in solidsby viscosity and slip between the particles. But magnetisation produces strain; hence we should expect that the phenomena of magnetostriction have viscosity and slip involved in them. If so, the theories of Kirchoff, Helmholtz, and Maxwell on the subject of magnetostriction (in which viscosity is ignored) must be faulty in part. The investigation is made as follows: Subject a soft iron wire to a fixed torque, corresponding to a definite deflection (δ) on a scale. Now magnetise the wire; the deflection changes, and when the field is removed the deflection is found to differ from δ. The author finds by investigation, (1) that in the presence of an impressed strain a longitudinal field produces increased rigidity and temporary set; (2) temporary and permanent set occur in twisting, just as in magnetisation.

The author suggests that the Ewing model representing magnetic strain should have the viscosity element introduced into it. A number of curves and tables are given. [See also Abstract No. 881 (1901).] P. E. S.

274. *The Frictional Resistance of Ether.* **M. Thiesen.** (Deutsch. Phys. Gesell., Verh. 3. 13. pp. 177–180, 1901.)—Experience confirms Maxwell's theory, that radiated light exerts, in the direction of its motion, a pressure equal to the energy per unit of volume. It is probable that the pressure so experienced by any body would be modified by motion of the body, and the author deduces this effect from the laws of radiation, following the same method as in the deduction of Wien's so-called law of displacements. If a train of waves falls, with angle of incidence $\cos^{-1}c$, on a plate in motion, the wave-length λ undergoes a change, $2\beta\lambda c/(1-\beta c)$, where β is the ratio of the velocity of the plate to that of light. The result which he obtains, using only the lowest powers of β, is that, for time dt and volume U,

$$\partial\lambda = \lambda\frac{fvdt}{\mathrm{U}}\left(\mp\frac{\beta}{3}-\frac{1}{4}\beta^2\right).$$

Two cases are considered; first, that in which the plate forms a closed or infinite surface, and is affected only on one side; secondly, that in which it moves in free space. The first case leads to Wien's displacements, the second, writing $y' = \beta v$ (the velocity of the plate), leads to a pressure per unit area, $p = 2\frac{y'}{\mathrm{U}}\mathrm{S}$, where S is energy. This is the pressure sought. It is shown to be very small, amounting for the earth's surface to not more than 1,000 kg., whence it follows that the influence of this resistance on the length of the year is of the order—

$$4{\cdot}3 \times 10^{-22}\mathrm{T}^4 \text{ seconds,}$$

T being the temperature in degrees Cent. S. H. B.

275. *On Absolute Motion.* **V. A. Julius.** (Archives Néerlandaises, 6. pp. 285–286, 1901.)—The author points out that when laws of motion are stated as representing actual results of experience, the motion must be relative to some definite medium or space. If we have two spaces or modes of defining space, one, A, defined by the co-ordinates x, y, z, with centre C, and the other, B, by the co-ordinates ξ, η, ζ, with centre O, and if the x, y, z co-ordinates of O be α, β, γ, and the direction cosines of the ξ, η, ζ axes referred to the x, y, z axes be a, a', a'', &c., then he expresses d^2x/dt^2 in terms of $\alpha, \beta, \gamma, a, a', a''$, &c., and shows that if there exists a potential for the field A, there is no potential for the field B unless a, a', a'', &c., are independent of the time.

In the writer's view, the medium to which all motion ought to be referred is the ether, and by absolute motion we should understand motion relative to ether. S. H. B.

276. *Determinations of Gravity on the Australian Continent.* **G. v. Neumayer.** (Archives Néerlandaises, 6. pp. 333–348, 1901.)—The author begins with a brief survey of pendulum work, pointing out a time of inactivity subsequent to Bessel and a new impulse given by Sterneck and others. The need for experiments in the Southern Hemisphere is pointed out, and the work of the Royal Society of Victoria, Australia, is referred to. A description of the author's experiments made in Melbourne forty years ago is given, and comparison is made between his results and those obtained at different places in Germany by means of similar apparatus. The pendulum was of the type suggested by Bessel as an improvement on the Kater-Bohnenberger instrument, and a specially constructed vertical comparator was used for determining the distance between the knife-edges. The values of l and g found were respectively, when reduced to sea-level, 0·9929120 metre and 979·965 $\frac{\text{cm.}}{\text{sec.}^2}$. Determinations made thirty years later by Baracchi are quoted, and a synoptic table of results obtained for Melbourne by Gubert, Elblein, Baracchi, Love, and the author is given. J. W. P.

277. *Reduction of Plumb-Line Observations.* **F. R. Helmert.** (Archives Néerlandaises, 6. pp. 442–447, 1901.)—The effect of hill ranges upon the value of gravity at different levels is considered, and formulæ are worked out. The case of a long range of rectangular section gives the result—

$$\Delta_1 - \Delta_0 = Kh_0 \left\{ \log \frac{4c^2+1}{c^2+1} + 4c \tan^{-1}\frac{1}{2c} - 2c \tan^{-1}\frac{1}{c} \right\},$$

where h_0 is the height, ch_0 the breadth of the section of the range, $\Delta_1 - \Delta_0$ the difference of deviation for bottom and top, and K a gravitation constant. Similarly an escarpment gives the result—

$$\Delta_1 - \Delta_0 = Kh_0 \left\{ \frac{\pi\beta + \beta^2 \log \beta^2}{\beta^2+1} - \log(\beta^2+1) \right\},$$

where β is the tangent of the angle of inclination to the vertical, and the rest of the notation is as before. Numerical results for the south slope of the Alps are appended, by which it is shown that $\Delta_1 - \Delta_0$ may have a maximum value of 5″. It is concluded that the results are not serviceable for effecting the reduction from Δ_0 to Δ_1 by observing the value of g at the foot of the range. J. W. P.

278. *Tides in the Macassar Strait.* **J. P. van der Stok.** (Archives Néerlandaises, 6. pp. 137–147, 1901.)—The results of observations of the tidal constants at the following stations are given: Macassar, Donggala, Tontoli, Balik Papan Bay, Moeara Djawa, Samarinda, Batoe Panggal, Boeloengan. These figures extend from 1895 to 1899, and are illustrative of peculiarities in the amplitudes and phases of the tidal components in these regions. After comparing all the results, the author concludes that the diurnal wave moves from north to south in the Macassar Strait, but with a velocity much less than that predicted by theory, and that the resultant semi-diurnal wave is not propagated in the strait at all, but is rapidly extinguished. The hypothesis is put forward that the tidal movement in the strait is the resultant of two elementary waves which, moving in the opposite direction, interfere differently as regards the diurnal and the semi-diurnal wave. J. W. P.

279. *Hygrometry.* **G. Guglielmo.** (Accad. Lincei, Atti, 10. pp. 193–202, Nov. 3, 1901.)—The paper describes a wet bulb method in which the constant is determined with accuracy by combining the results of observation with an ordinary wet bulb with those derived from a similar bulb wetted with a solution, say of sulphuric acid, of known vapour tension at the given temperature. There is a discussion of experimental errors and of means for ensuring compensation of these. A. D.

280. *St. Maurice Meteorological Observations during* 1900. **R. Gautier.** (Archives des Sciences, 12. pp. 265–300, Sept., 514–534, Nov., and pp. 587–601, Dec., 1901.)—In the fortifications of St. Maurice on the Rhône, observations are taken at two second order stations, Savatan and Dailly, and two pluviometer stations, l'Aiguille (elevation 1,446 m.), and Lavey (lower down). The temperature means are calculated from the arithmetical means of the three daily readings at 7 a.m., 1 p.m., and 9 p.m., and also by counting the 9 p.m. reading twice. Temperature inversions between the two stations, which differ in elevation by 563 m., are most frequent in December. The annual barometric means for the two stations are 702·9 and 656·6 mm., the extremes 715·8 mm. (December 16, 1900) and 636·9 (January 29th). The nebulosity is greater in winter than in summer. September is the clearest month. The maximum rainfall was observed at Dailly, 1,126 mm. on 193 days; most snow fell at l'Aiguille, 895 cm. on 59 days. References are made to Geneva and to the Great St. Bernard. H. B.

281. *Sun-spots and Planetary Disturbances.* **Birkeland.** (Comptes Rendus, 133. pp. 726–729, Nov. 4, 1901.)—In continuation of the author's previous attempts to trace any existing influence of the gravitational action of the planets on the production of sun-spots [see Abstract No. 1245 (1901)], he has examined the records from 1892–1896. After considering the facts with relation to Mercury, Venus, Jupiter, and Saturn, the conclusion is that the eleven-yearly period is not dominated by planetary disturbances.

C. P. B.

282. *Observations during Total Solar Eclipse, January* 22, 1898. **J. N. Lockyer, Chisholm-Batten,** and **A. Pedler.** (Roy. Soc., Proc. 68. p. 6, March 5, 1901 (Abstract); Roy. Soc., Phil. Trans. 197. pp. 151–227, Oct. 3, 1901.)—The paper contains a full report on the preparations, instrumental equipment, spectroscopic and other observations, and discussions of these in relation to laboratory work. The chief spectroscopic instruments employed were two prismatic cameras, of 6 and 9 inches aperture. The photographs obtained with the 6-inch instrument have been reduced, and a table is included of the determined wave-lengths of 856 lines between $\lambda5896(D_1)$, and $\lambda3663$, with their probable origins, obtained from comparison spectra photographed in the laboratory with the same instrument provided with a collimator and slit.

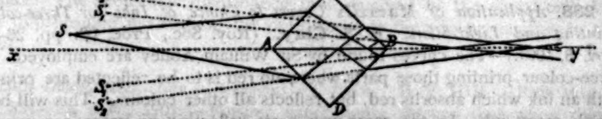
The coronal radiations have been classified into three groups, distinguished by having their maxima of intensity in different position angles. The three radiations at $\lambda\lambda5303{\cdot}7$, 3987, and 4359·5 are typical of the three groups. Reproductions of the corona photographs and the spectra with the prismatic cameras accompany the paper. C. P. B.

LIGHT.

283. *Cornu's Criticisms of the Revolving Mirror Method of Measuring the Velocity of Light.* **H. A. Lorentz.** (Archives Néerlandaises, 6. pp. 308–318, 1901.)—Cornu, in a recent paper [see Abstract No. 776 (1901)], throws doubt upon the trustworthiness of results obtained by this method, on the grounds—(1) that the revolving mirror may be expected to drag the luminous beam with it to a small extent, and thus make the deduced velocity too small; (2) that the beam incident on the fixed mirror moves across it with a velocity comparable to that of light; (3) that the aerial vortex around the revolving mirror may modify the path of the rays. As regards (1), the author shows, by a direct application of geometrical optics, that the effect of the rotation is to alter slightly at each instant the distance between the centre of the revolving mirror and the image formed by reflection, but not to alter the direction in which this image lies; the angle of reflection is therefore not modified. As regards (2), he calculates that the velocity with which the beam traverses the fixed mirror was 0·0013 of the velocity of light in Michelson's experiment, and 0·082 in Newcomb's, and maintains that, even if much greater, it would not affect the directions of the reflected rays. A long discussion follows respecting the influence of diffraction, leading to the inference that diffraction impairs the sharpness of the final image, but does not displace it. As regards (3), the author maintains that the inequality of density of the air in the vortex, being symmetrically distributed round the axis of revolution, will not tend either to advance or retard the direction of either the incident or reflected beam; and that even if the distribution is unsymmetrical, its influence on the beam as sent out will be exactly compensated by its influence on the returning beam. Finally, as regards the dragging of waves of light by the vortex, Foucault's assumption of $1-1/v^2$ as the factor of dragging, applied to a supposed velocity of 200 metres per second of the revolving air, would only make a difference of 12 cm. per second in the deduced velocity of light.

A. E.

284. *Application of Govi's Camera Lucida.* **A. Lafay.** (Comptes Rendus, 133. pp. 920–921, Dec. 2, 1901.)—The property of the prism ABCD, that the images S_1, S_2', and S_2, S_1' coincide only when the plane of half the silvered surface AB contains the source S, is employed in an arrangement for testing scales and planes. Two sources are placed 8 metres apart, with the prism midway, the plane AB being on the line joining the two sources, which are viewed through the prism by two telescopes, and two mirrors placed at 45° to the joining line. The prism is provided with a micrometer screw, and a pointer to touch the plane being tested, and an accuracy of 0·01 mm. is easily obtained. [See also Abstract No. 1415 (1900).]



G. E. A.

285. *Metallic Reflection of Ultra-Violet Radiation.* **P. G. Nutting.** (Phys. Rev. 13. pp. 193–202, Oct., 1901.)—The paper contains a detailed study, with photographs, of the spectrum as reflected from various metals, glass, quartz, cyanin, carbon bisulphide, benzine, and other liquids. The reflecting power of silver falls off to a rather sharp minimum of 10 per cent. between 320 and 324 $\mu\mu$; and corresponding to this the spectrum between 310 and 340 is quite freely transmitted by a coating of silver on quartz so thick as completely to absorb all other radiation between 300 and 185. There is also another minimum (less than 10 per cent.) of reflection at 185 $\mu\mu$. The reflecting power of other metals, notably mercury, remains high and nearly constant, falling off but slightly in the neighbourhood of wave-length 185. Glass does not show metallic reflecting power in the region in which its absorption is very great; its properties in this respect are like those of solutions. A. D.

286. *Radiation of Black Bodies.* **F. Paschen.** (Ann. d. Physik, 6. 3. pp. 646–658, Nov., 1901.)—This is a controversial paper, defending the author's conclusions [see Abstract No. 1049 (1901)] against O. Lummer and E. Pringsheim [see Abstracts Nos. 1290 and 2356 (1901)]. A. D.

287. *The Green Ray.* **W. H. Julius.** (Archives Néerlandaises, 6. pp. 385–389, 1901.)—As is well known, the last rays of the setting, or first rays of the rising, sun sometimes appear green or bluish green. The explanation which first suggests itself is that the green ray is due to dispersion resulting from astronomical refraction. Bessel's tables give for the deviation of a ray by the earth's atmosphere 2094″ near the horizon. For air the refractive index n_D is 1·00029289, and $n_F - n_C = 0{\cdot}00000295$, whence we have for the dispersive power $\frac{n_F - n_C}{n_D - 1} = \frac{1}{99}$. The violet and blue rays are strongly absorbed by the atmosphere, and the length of the green portion of the spectrum may be taken as half the interval F to C. Hence, near the horizon, we should expect to see the sun edged by a green border of width $\frac{2094''}{200} \doteq 10''$. At the tropics the sun descends 15″ per second, which would make the visible duration of the green ray $\frac{2}{3}$ sec. The times quoted by observers are generally greater than this, and vary considerably. The author therefore does not consider this explanation satisfactory, adding further that it does not account for the rarity of the phenomenon. He suggests another explanation depending on anomalous dispersion produced by free ions in the upper regions of the atmosphere. A. E.

288. *Application of Maxwell's Curves to Choice of Inks for Three-colour Printing and Light-filters.* **R. S. Clay.** (Roy. Soc., Proc. 69. pp. 26–60, Nov. 8, 1901.)—The curves found by Sir William Abney are employed. In three-colour printing those parts where no red is to be reflected are printed with an ink which absorbs red, but reflects all other colours. This will be a bluish green ink. In the same way, parts reflecting no green are printed with a pink ink which absorbs green, and parts reflecting no violet with a yellow ink which absorbs violet. The author finds it is important that the three absorption bands, red, blue, violet, corresponding to the three inks, should join abruptly end to end, and not overlap. A moderate admixture of white with the tints is not perceived by the eye; addition of black makes the

colours "dirty." In production of colour by successive absorption, the loss of light proceeds by geometrical progression, not by successive subtraction. This is important in "process" three-colour printing, for there the inks are always printed full strength, and the tint is regulated by the size of the dots, that is, by the area covered by the ink. It is practically impossible to control the relative placing of dots of different colours. This will be immaterial if the spectral absorption regions of the three inks do not overlap, but if they do overlap, then where dots of different colours coincide there will be blackness, and the colouring will only be correct when the dots fall clear of one another. Further reasons for using inks with abrupt absorption are that the colours will be purer, and that variation in the amount of ink from impression to impression will not be so important, thus avoiding a great practical difficulty. Assuming that the absorptions should be abrupt, the author proceeds to discuss the best limits, and places them at about $\lambda 49$ and $\lambda 59$. He finds that to make the luminosities balance, the absorption band of the green-absorbing ink should be a good deal narrower than the region covered by the green sensation. Thus the tints of the inks will not be truly complementary to the three-colour sensations. The red-absorbing ink should nearly match the green at $\lambda 50{\cdot}3$. A study of the curves for theoretical inks shows that the light-filters for three-colour printing should be entirely different from those used for three-colour projection. A theoretical ink is defined as one which is perfectly transparent until the absorption commences, and then is perfectly opaque. As this condition is rarely fulfilled in practice, the author determined curves for actual inks experimentally. By means of Abney's Colour Patch apparatus he measured, throughout the spectrum, the proportion of light of each colour that was reflected by several commercial inks. One pink ink (Fleming's No. 1303) fulfilled the theoretical conditions satisfactorily, also one yellow ink (Fleming's No. 1271), but all the blue inks were found too opaque in the green. A. E.

289. *Mechanical Theory of Vision.* **A. Pizon.** (Comptes Rendus, 133. pp. 835–837, Nov. 18, 1901.)—For the usual theory of vision based on a chemical action exerted by light the author proposes to substitute a *mechanical theory.* In all the visual organs of vertebrates and invertebrates the pigmentary granules which always accompany the visual cells are always animated by rapid movements comparable to those of certain micrococci. The general presence of these granules in immediate contact with the visual cells, and the constancy of their movements, lead to the supposition that they serve as intermediaries for the excitation of these visual cells. The granules obtain their energy from light under the form of a vibratory movement, which they transmit in their turn to the cones or to the rods with which they are in contact. The molecular disturbance thus received by the visual cells has only to propagate itself along the optic nerve to the nervous centres in the brain. J. J. S.

290. *Double Refraction in Solutions of Colloids.* **B. V. Hill.** (Phil. Mag. 2. pp. 524–527, Nov., 1901.)—Former experiments showed that when dilute solutions of gelatine and gum-arabic in water are strained by continued movement they become doubly refracting [see Abstract No. 36 (1900)]. The present paper deals with strain produced statically. The dilute jellies were placed in thin brass tubes closed by glass plates at the ends, and were strained by squeezing the tubes between clamps so that their cross-section was elliptical. As the double refraction decreases rapidly with increase of temperature, the tubes were surrounded by ice for from 16 to 48 hours, the plates at the ends being protected from dewing. Solutions of 0·8 grm. and 0·5 grm. in 100 c.c. were employed. A solution of 0·2 grm. showed only a trace of double refraction after 48 hours in ice. A 0·1 grm. solution gave effects after 120 hours. From the results it is seen that the double refraction increases with the compression up to a certain point, beyond which it remains stationary, and then diminishes. Thus the solutions behave like solids capable of sustaining only a very small amount of strain. When this amount is exceeded, disruptive action takes place, and the strain diminishes. The solid structure grows with the time, and more rapidly in the more concentrated solutions. There are indications that the structure does not grow uniformly throughout the liquid at earlier stages, but afterwards becomes more homogeneous. Depolarisation appears, but greatly decreases at a later stage. The fact that the plane of polarisation is not always rotated in the same direction might be explained by supposing internal strains due to non-homogeneity to be actually relieved by the compression. A. E.

291. *Resolving Powe*r *of Echelon Spectroscope.* **P. Zeeman.** (Archives Néerlandaises, 6. pp. 320–322, 1901.)—This is an attempt to furnish some data for the comparison, desired by Rayleigh, between the actual resolving power of a spectroscope and that given by the theoretical formula. The observations were taken with an echelon spectroscope by Hilger, having 30 plates 7·8 mm. thick, with 1 mm. width of step. Defining resolving power as the value of $\lambda/d\lambda$ for bare separation, its theoretical value is $\frac{\kappa nt}{\lambda}$, where n denotes the number of plates (plus one, if there is also an air space equal in width to one step), t the thickness of a plate, and $\kappa=\mu-1-\lambda\frac{d\mu}{d\lambda}$. For the green mercury ray ($\lambda=5460$) this gives $8{\cdot}8\times10^{-6}$ as the theoretical value of the limiting $\frac{d\lambda}{\lambda}$. In absence of knowledge of the difference of wave-lengths of the fine mercury lines near 5460, the green radiation of thallium was observed, with the result that, of two faint lines near the strong one, the one at distance $\frac{d\lambda}{\lambda}=21\times10^{-6}$ was easily seen, but the one at $\frac{d\lambda}{\lambda}=3\times10^{-6}$ could not be detected. The theoretical limit (λ being 5440) is $3{\cdot}75\times10^{-6}$. The green line of cadmium ($\lambda=5086$) consists of two components, for which, according to Fabry and Pérot, $\frac{d\lambda}{\lambda}=5\times10^{-6}$, and the theoretical limit is $3{\cdot}5\times10^{-6}$. This test was suggested, but was not made. The author thinks the most promising method for applying tests of gradually increasing severity, is by gradual variation of the strength of a magnetic field, and quotes Blythswood and Marchant [see Abstract No. 1019 (1900)] in support of this contention. A. E.

292. *Properties of Certain Systems of Photographic Lenses.* **R. Sissingh.** (Archives Néerlandaises, 6. pp. 390–403, 1901.)—The method developed by Bosscha is employed to give a simple treatment of the properties of simple lenses, tele-objectives, and hyperachromatic lenses. For an infinitely thin lens without a diaphragm, the luminous intensity is proportional to D^2/F^2 where D is the diameter and F the focal length of the lens. For the same case with a diaphragm, the luminous intensity is given by the expression $IS p^2 \Big/ \left(1-\frac{\xi'}{\xi}\right)^2$, where I is the intensity of the object, S the aperture of the diaphragm, ξ the distance from object to principal focus, ξ' the distance from diaphragm to same focus, and p is an optical constant representing the power of the system. Particular cases of this result are considered, and then the tele-objective is discussed. This consists of two systems of lenses, the one convergent and the other divergent, placed at some distance apart. Expressions for the focal distance and magnification are worked out, and the following advantages are claimed for them: (1) The same magnification as in the case of simple lenses is secured at greater distances; (2) the image distance is smaller under corresponding circumstances. The size of the dark chamber of the camera can thus be reduced. Also the perspective is less exaggerated in the image. The case of deformation of the images produced by symmetrical and semi-symmetrical objectives is then considered; and lastly hyper-achromatic lenses are dealt with under three heads: (*a*) Both constituents positive; (*b*) one positive, the other negative; (*c*) both negative.

J. W. P.

293. *Distribution of Energy in Spectrum of Acetylene Flame.* **G. W. Stewart.** (Phys. Rev. 13. pp. 257–282, Nov., 1901.)—This paper contains a determination of the distribution of energy in the spectrum of the flame, found by means of the spectrometer and radiometer. Observed and corrected curves of intensity are given for the cylindrical flame from a single-tip burner, and for the flat flame from a two-jet burner. The radiant efficiency of the cylindrical flame was found to be 0·100, while that of the flat flame was found to be distinctly higher.

E. C. C. B.

294. *Spectroscopic Determinations at Total Solar Eclipse, January* 22, 1898. **J. Evershed.** (Roy. Soc., Proc. 68. pp. 6–9, March 5, 1901 (Abstract); Roy. Soc., Phil. Trans. 197. pp. 381–413, Nov. 16, 1901.)—Detailed particulars are given of the complete examination of a series of spectra photographed during the total eclipse of the sun at Talni, India. Ten photographs were obtained at various stages of the phenomenon, the exposures being given in relation to the position of the moon so as to record the spectra of prominences, chromosphere, or corona. The instrument used was a small prismatic camera, the objective having an aperture of 50 mm. and focal length of 890 mm.; outside this there were adjusted two crown-glass prisms each of 60° refracting angle. The effective aperture of the prisms was about 42 mm. Immediately before totality (20 secs. and 10 secs.), photographs were obtained of the Fraunhofer spectrum furnished by the last segment of the photosphere. These served as reference spectra in the subsequent reductions. After this, the chromospheric spectrum at second contact was obtained; the negative shows 313 lines, the wave-lengths and origins of which are given in tabular form. Measurements of the arcs of many of the chief lines indicate a depth of $1''\cdot3$ for the gaseous stratum producing the "flash" spectrum, and the total depth of the chromosphere is given as $8''\cdot2$ when measured from hydrogen arcs, and $11''\cdot6$ from calcium arcs. A photograph taken just after this stage shows only the upper chromosphere and larger prominences. A conspicuous feature of the spectrum of two of these latter is a long band of continuous radiation, beginning near $\lambda3668$, where the ultra-violet hydrogen series ends, and extending indefinitely into the ultra-violet. A plate exposed for 40 secs. near the middle of the eclipse shows, in addition to the chief corona line at $\lambda5303\cdot3$, a

second near λ3388, with the maxima of intensity at similar positions. A lengthy discussion is included dealing with the assignation of origins to the recorded lines, and the arrangement of the elements found into groups according to their atomic weight. Three plates accompany the paper, showing the varying spectra of the solar surroundings during the progress of the eclipse.
C. P. B.

295. *Banded Spectra of Metals.* **W. N. Hartley** and **H. Ramage.** (Roy. Dublin Soc., Trans. 7. pp. 339–352, Oct., 1901.)—Photographs are given of the flame spectra of many metals which show very beautiful bands, and from their results the authors conclude that metals of very different characters yield spectra which are banded, or contain both distinct lines and bands—for example: magnesium, zinc, and cadmium; copper, silver, and gold; and others. Combustible metals giving stable and only slightly volatile oxides give banded spectra, also metals with volatile oxides, and also those metals which are not oxidised at the temperature of the flame. Certain metals give bands degraded towards the less refrangible end of the spectrum, *e.g.*, copper, silver, and gold; aluminium and indium; beryllium and lanthanum. Others give bands degraded on the more refrangible side, *e.g.*, magnesium, zinc, and cadmium. Elements belonging to the same group in the periodic table show in their spectra similarly constituted bands. Banded spectra are thus connected with the periodic law. E. C. C. B.

296. *Photographs of Spark Spectra.* **W. E. Adeney.** (Roy. Dublin Soc., Trans. 7. pp. 331–338, Sept., 1901.)—This paper deals with the ultra-violet spark spectra of iron, cobalt, nickel, ruthenium, rhodium, palladium, osmium, iridium, platinum, potassium chromate, potassium permanganate, and gold. A series of photographic reproductions are given of spark spectra taken in the first order with a 21·5-feet focus Rowland grating between λ4550 and λ2200. The spectra were produced by means of an Apps 10-inch spark coil with a current of 10 amperes and a condenser of 144 square feet area. In the case of the liquids platinum electrodes were used. E. C. C. B.

297. *Sensitive Paper in Röntgen Ray Work.* **M. I. Wilbert.** (Frank. Inst., Journ. 152. pp. 463–467, Dec., 1901.)—The author recommends glossy bromide paper, particularly that of the Neue Photographische Gesellschaft, Berlin. Paper has the advantage in respect of price, non-liability to breakage, storage, recording—making, say, a dozen at a time by exposing a whole packet instead of one piece—and the rapidity with which an intelligent result can be obtained, since if there be thorough rinsing in water the paper can be examined even in daylight before fixing; and glossy bromide paper brings out details in a way the ordinary "smooth" paper does not. A. D.

298. *Chemical Reaction Produced by Radium.* **Berthelot.** (Comptes Rendus, 133. pp. 659–664, Oct. 28, 1901.)—The radiation from radium decomposes I_2O_5 and HNO_3. These are both endothermic reactions, and are caused likewise by light. On the other hand, radium radiation does not cause the separation of insoluble sulphur from a solution of the soluble variety in carbon disulphide, as light does, nor does it cause the condensation of acetylene, like the silent discharge. Furthermore, it does not accelerate the oxidation of oxalic acid in solution, like light, but it produces a peculiar discolouration in lead glass, apparently inducing the reduction of the lead and the oxidation of the manganese simultaneously. F. G. D.

299. *Chemical Effects Produced by Radium Radiation.* **H. Becquerel.** (Comptes Rendus, 133. pp. 709–712, Nov. 4, 1901.)—In view of Berthelot's recent researches (see preceding Abstract) on the chemical effects of radium radiation, the author has now published the results of experiments made some time ago. The first deals with the phenomena of colouration, observed by M. and Mme. Curie, on glass, porcelain, and paper, when exposed to radium rays. With a small tube first coloured by exposure to radiation, then deprived of its colour by heating, the author obtained a violet colouration, while a portion of the tube which had not been heated became brown in colour, gradually tending to violet during a period of six months, although the tube was kept out of the action of light. Among the phenomena which are accompanied by a giving out of heat, the first mentioned is the transformation of white phosphorus into red under the influence of radium radiation. In a similar manner, bichloride of mercury in the presence of oxalic acid is reduced by the radiation, and a precipitate of calomel is formed. The quantity precipitated varies in different experiments. Experiments made in the author's laboratory by Louis Matout on the germination of seeds of mustard and garden cresses exposed to radium rays before being planted, show an absence of germination in the seeds planted after exposure for a week or more, while of others kept under identical conditions, but not exposed to radiation, and planted at the same time, 80 per cent. germinated. Thus prolonged exposure has destroyed the faculty of germination. [See also Abstract No. 1257 (1900).] W. C. H.

300. *Induced Radio-activity and Atmospheric Air.* **H. Geitel.** (Phys. Zeitschr. 3. pp. 76–79, Nov. 15, 1901. Paper read before the 73rd Naturforscherversammlung at Hamburg.)—The author describes experiments which, with the previous ones of himself and Elster [see Abstracts Nos. 1918 and 2352 (1901)] incline him to adopt the hypothesis that atmospheric air itself possesses radio-active properties of its own. J. J. S.

301. *Phosphorescence under the Influence of Kathode Rays.* **A. Schmauss.** (Phys. Zeitschr. 3. pp. 85–87, Dec. 1, 1901.)—The capacity of various substances for phosphorescing under the action of kathode rays diminishes after a short exposure to the radiation. The cause of this fatigue was investigated by the author. The temporary fatigue which most substances exhibit is due to the heating under the influences of the kathode rays, by which the phosphorescing substances are quickly raised above the temperature of their maximum light emission, this temperature being in most cases not very high. The lasting fatigue is due in the case of some substances (such as Balmain's luminous paint and chalk) to the effect of heat. In a second group of substances (including glass) the permanent fatigue probably resembles the change of colour of the haloid salts of the alkalis, and is of a chemical nature. Thus glass can be brought back to its original state by heating it to bright redness, as under similar treatment the salts referred to regain their original colour. The temperature of maximum phosphorescence was determined for various substances. For example, the maximum in the case of Balmain's paint was found to be about 70°. J. J. S.

REFERENCE.

302. *Dispersion of Ultra-Violet Rays.* **F. F. Martens.** (Ann. d. Physik, 6. 3. pp. 603–640, Nov., 1901.)—An elaborate series of tables is given, showing the indices of refraction of various substances for different wave-lengths. J. J. S.

HEAT.

303. *Thermometers.* **W. Schloesser.** (Zeitschr. Instrumentenk. 21. pp. 281–298, Oct., 1901.)—A detailed account is given of comparative tests of thermometers of different kinds. The mean of a number of thermometers of *verre dur* agrees very well with the air-thermometer. The errors depend a good deal upon the chemical constitution of the glass. A. D.

304. *Determination of Very Low Temperatures.* **H. Pellat.** (Comptes Rendus, 133. pp. 921–924, Dec. 2, 1901.)—A gas thermometer is not available for very low temperatures, because of the increasing deviation with cooling of the properties of the contained fluid from those of a perfect gas. The general method proposed by Lippmann (Journ. de Phys., 2nd series, t. III. p. 277, 1884) is impracticable with very low temperatures. The author proposes to use the Peltier effect. A thermoelectric couple (preferably iron and zinc) the e.m.f. E in c.g.s. units; one of its junctions is maintained at a constant temperature, *e.g.*, that of melting ice, while the other is carried to the temperature T to be evaluated.

If Π is the Peltier effect, Kelvin's formula then gives $\Pi = \mathrm{T}d\mathrm{E}/d\mathrm{T}$, or $d\mathrm{T}/\mathrm{T} = d\mathrm{E}/\Pi$. If now E and Π are known as functions of the temperature, in the forms $\mathrm{E} = f(t)$ and $\Pi = \mathrm{F}(t)$, then $d\mathrm{T}/\mathrm{T} = f(t)/\mathrm{F}(t) = d\phi(t)/dt$, and $\phi(t)$ is known. Then T is determined in terms of T_0 by the equation—

$$\log \frac{\mathrm{T}}{\mathrm{T}_0} = \phi(t) - \phi(t_0).$$

A description is then given of the apparatus employed in practice. S. H. B.

305. *Emissivity of Platinum at High Temperatures in High-pressure Gases.* **J. E. Petavel.** (Roy. Soc., Proc. 68. pp. 246–247, June 24, 1901 (Abstract); Roy. Soc., Phil. Trans. 197. pp. 229–254, Oct. 23, 1901.)—The rate of cooling of a hot body in gases at high pressures was investigated in the experiments here described, as up to the present data on this subject have not been available. The experiments were carried out with a horizontal cylindrical radiator, contained in a strong steel enclosure, the enclosure being maintained at about 18° C. by a water circulation. The method and apparatus are the same as those described in the previous parts of the author's account of his research on the emissivity of platinum [see Abstract No. 1017 (1899)]. It is shown that the rate at which heat is dissipated by the radiator may be expressed by the following formula:—

$$\mathrm{E} = ap^{\alpha} + bp^{\beta}\theta,$$

where E = emissivity in c.g.s. units = total amount of heat dissipated in water-gramme-degrees per sq. cm. of surface of radiator per second; p = pressure in atmospheres; θ = (temperature of radiator) — (temperature of enclosure), *i.e.*, the temperature interval in degrees Centigrade. The limits between which the formula may be considered to hold good and the numerical value of the constants for the various gases studied are given in the following table :—

	$a \times 10^6$	$b \times 10^6$	α	β	The formula holds good			
					from $\Theta =$	to $\Theta =$	and from $p =$	to $p =$
Air	403	1·63	0·56	0·21	100	1100	7	170
Oxygen	387	1·39	0·58	0·28	100	1100	15	115
Hydrogen	2705	1·88	0·35	0·36	300	1100	7	113
Nitrous oxide	276	1·70	0·74	0·28	100	800	5	40
Carbon dioxide	207	1·50	0·82	0·33	100	1100	10	35

The emissivity in different gases at various pressures and with different temperatures of the radiator is given in a series of tables, and its variation with temperature and pressure is also expressed by means of curves. The question as to what proportion of the total loss of heat is due respectively to convection, conduction, and radiation is treated at some length in the paper. The influence of experimental conditions, such as the temperature of the gas and the dimensions of the radiator and enclosure, is also studied. All gases show a rapid increase of the effective conductivity with the pressure. In air, for instance, the rate of cooling is six times greater at 100 atmospheres than it is at atmospheric pressure. The effect of the high rate at which heat is transmitted through compressed gases is discussed, both from a theoretical and a practical point of view, and the bearing of the results on some problems of modern engineering is considered. J. J. S.

306. *Laws of Radiation at Low Temperatures.* **Compan.** (Comptes Rendus, 133. pp. 813-815, Nov. 18, 1901.)—Experiments were made on the cooling of a ball of copper, 2 cm. in diameter, blackened and of maximum emissive power, in which was plunged a junction of a copper-constantan couple, the two wires of which permitted of suspending it at the centre of a glass globe 8 cm. in diameter. A vacuum could be produced in this globe, or it could be filled with dry air at different pressures. The vacuum being first of all pushed to its extreme limit, the ball was heated without removing it from the globe, by projecting on it, by means of a lens, the positive crater of an electric arc. In this way its temperature could be made to exceed 320°. The globe was plunged in melting ice, in a mixture of solid carbonic acid and ether, or in liquid air; the second junction of the couple being placed in the cooling agent. The author measured the rate of cooling with different ranges of temperature between 302° and —182°·5, and compared the values obtained with the formulæ of Dulong and Petit, of Stefan, and of Weber.

1. The formula of Dulong and Petit, viz., $m = v/a^{\theta}(a^{t} - 1)$ where $a = 1{\cdot}0077$, $\theta =$ temperature Centigrade of the enclosure, $t =$ excess of the temperature of the cooling body over that of the enclosure, m being a constant—does not apply to the results obtained by the author, except in the interval from 0° to 200°. On taking for m the mean of the values given in this interval, the calculated velocities on either side would be higher than those observed. 2. The formula of Stefan—$m = v/T^4\Theta^4$, T and Θ being the absolute tempera-

tures of the body and of the enclosure, is the one which agrees best with the results from the temperature of boiling liquid air up to 302°, yet from 150° to 300° it would give velocities a little too high. 3. The formula of Weber—$m = v/T_n^T \Theta_n^\Theta$, where $n = 1{\cdot}0042$, does not apply to low temperatures, but from about 100° to the highest temperature observed (302°) it represents the phenomenon better than the formula of Stefan. J. J. S.

307. *The Radiation Laws and the Determination of Temperature.* **O. Lummer** and **E. Pringsheim.** (Phys. Zeitschr. 3. pp. 97–100; Discussion, p. 100, Dec. 1, 1901. Paper read before the 73rd Naturforscherversammlung at Hamburg.)—Referring to the investigations of the authors on dark radiation, the question is discussed whether the radiation laws can be made serviceable for temperature determinations. The radiation laws furnish a new temperature scale, which is identical at low temperatures with the usual gas thermometer scale, but can be utilised at much higher temperatures than the method of the gas thermometer permits of. The following three radiation laws are mentioned :—

(1) $\int_0^\infty E_\lambda d\lambda = \sigma T^4$ (Stefan-Boltzmann). (2) $\lambda_m T = A$. (3) $E_m T^{-5} = B$.

E_λ is the portion of the dark radiation for the absolute temperature T contained between the wave-lengths λ and $\lambda + d\lambda$, whilst λ_m is the wave-length for which, with this temperature, the energy E_λ in the normal spectrum has its maximum E_m; σ, A, and B are determined constants.

In the experimental corroboration of these laws the temperature was measured with the help of a Le Chatelier thermo-element which was compared by Holborn and Day with the gas thermometer up to 1,150° C., the highest temperature which up to the present has been exactly measured with the gas thermometer scale. By extrapolation of the empirical formulæ for the thermoelectromotive force, the comparison of the above laws can be continued to over 1,400° C. This investigation may be regarded as a standardisation of the thermo-element between 1,150° and 1,400° C. by means of the new temperature scale founded on the radiation theory. The thermoelectromotive force is found to follow the same law which held good at lower temperatures measured by the gas thermometer. In order to set forth the temperature scale above these limits, it is necessary to produce the dark radiation up to the highest possible temperature attainable in the experiment. With this object a dark body has been devised in which a carbon tube made to glow by the electric current sends out the radiation. A stopper of carbon serves as radiating surface, through which also a thermo-element can be led into the interior. On the outside, in order to protect the carbon from combustion, the tube, as much as possible hermetically sealed, is surrounded by another carbon tube electrically insulated from it. In order to hinder the entrance of atmospheric oxygen though the radiation opening in the interior of the tube, a metal covering is laid before the opening which is traversed by a slow stream of nitrogen. In this way it is possible for carbon tubes of 1·5 to 0·75 mm. thickness of wall to glow for hours together, without the strength of the wall being markedly diminished. In order to hinder as much as possible the escape of heat to the outside, the carbon tube is surrounded with many folds of a difficultly fusible substance containing air-spaces. To measure the temperature of this dark body either of the laws given above will serve. If the temperature is determined, it may be expected, through measurement of the distribution of energy, to gain a further proof of the law of radiation, and a more exact elucidation of the validity of Planck's equation. J. J. S.

308. *Cooling Power and Conductivity of Air.* **P. Compan.** (Comptes Rendus, 188. pp. 1202–1204, Dec. 28, 1901.)—In Dulong and Petit's formula, $np^c t^b$ for the factor of cooling due to the air (p = pressure, t = the excess of temperature, n a constant for a given substance), with a blackened copper ball of 2 cm. diameter in a flask of 16 cm., $b = 1{\cdot}232$, and $c = 0{\cdot}45$ (the same numbers as those of Dulong and Petit), so long as p is above 15 mm., but at pressures below 15 mm., both b and c increase rapidly. With the same ball in a flask of 8·3 cm., $b = 1{\cdot}154$ and $c = 0{\cdot}30$, so long as the pressure remains above 50 mm. (Desains found variations in the values of b and c.) When the speed of cooling ν becomes independent of the pressure, there are no convection currents, and the cooling is due to conductivity ($\nu = \nu_1$, say); then if ν_2 be the same so far as due to radiation, K the conductivity of air, γ the coefficient of temperature, P the weight of the ball, c the specific heat of the hot ball, e the thickness of the gas-wall, S the surface of the ball,

$$K = \frac{Pce}{tS}(\nu_1 - \nu_2).$$

From 300° to 0° the values of K correspond to a straight line which gives $K_0 = 0{\cdot}0000479$ at 0° C. and $\gamma = 0{\cdot}00130$. The value of K_0 confirms previous results; that of γ is smaller, but shows that $Kt/K_0 = \sqrt{T/T_0}$, in conformity with Clausius's theory. A. D.

309. *Critical Velocity of Liquids.* **H. T. Barnes** and **E. G. Coker.** (Phys. Rev. 12. pp. 372–374, 1901.)—H. T. Barnes showed (Roy. Soc., Proc. 67, 238, 1900) [see also Abstract No. 2357 (1901)], that if water be heated while flowing through tubes at velocities less than the critical velocity, so that the motion is in the form of parallel stream-lines, then the distribution of heat is not uniform; that where the heat is applied to the outside of the tube, only a few layers of the water in direct contact with the tube will be heated, the influx water passing through the centre unheated; and that where the heat is received from a central wire, the hot water flows along the wire, leaving the sides of the tube unheated. For flows beyond the critical velocity, the flow is eddying and sinuous and the distribution of heat throughout the water-column is uniform. The authors now find that the sudden passage from direct to sinuous motion is very sharply determined by placing the bulb of a sensitive mercury thermometer in the path of the moving column of water just as it emerged from the tube; when the motion becomes sinuous, even for an instant, the mercury-column shoots up, and the break-down of the stream-line motion thus shows the attainment of the critical velocity. A. D.

310. *Expansion by Heat of Solutions of Magnesium Chloride.* **G. J. W. Bremer.** (Archives Néerlandaises, 6. pp. 455–470, 1901.)—Observations were made of the density at different temperatures of solutions of magnesium chloride of various concentrations. Expressing the relation between the density d at $t°$ and the density d_0 at 0° by the equation

$$d = d_0(1 - at - bt^2),$$

the values of the constants a and b are calculated from the observations in various cases. The general result obtained is that the coefficient a increases, and then diminishes, with increasing concentration. This fact leads to the conclusions that (1) the more concentrated the solution the more regular is the expansion, and (2) if the expansion of two solutions of different concentration be compared, the two having equal volumes at 0°, it will be found that the more concentrated solution expands more at first, but as the temperature rises, the difference between the expansions diminishes, and finally, the less concentrated solution expands more than the other. Also, in the case of chloride of magnesium, the curves which represent the law of expansion have nearly the same point of intersection.

The results agree with Tammann's conclusion that, as regards expansion, solutions behave like water under high pressures. The solution of a substance in water has for the water the same effect as if it were subjected to a definite pressure, the value of the pressure depending on the temperature. J. J. S.

311. *Fusion and Crystallisation. Modification of Tammann's Theory.* **P. Duhem.** (Archives Néerlandaises, 6. pp. 93–102, 1901.)—Tammann has shown that, in the case of superfused substances, the readiness with which crystallisation takes place at first increases as the temperature falls, but reaches a maximum, and then becomes much less at lower temperatures. He has therefore suggested that at a sufficiently low temperature, the crystalline state would no longer be stable, but that the substance would pass again into the isotropic (viscous liquid) state; this temperature has been called the "second point of fusion." It is now suggested that the "second point of fusion" represents the upper limit of temperature at which the isotropic and crystalline forms can exist together in false equilibrium (like an explosive mixture of hydrogen and oxygen below the temperature of ignition), but that the crystalline, and not the isotropic, form would be the stable modification at temperatures below this point. T. M. L.

312. *Equation of State.* **J. D. van der Waals.** (Archives Néerlandaises, 4. pp. 299–318, 1901.)—In the first part of this paper the author discusses the variation with volume of the quantity b, which enters into his equation of state, and which is equal to four times the volume of the molecules when the volume is very great. He deduces the value—

$$b = b_\infty \left\{ 1 - \frac{17}{32}\frac{b_\infty}{V} + \epsilon_1\left(\frac{b_\infty}{V}\right)^2 \text{\&c.} \right\},$$

where b_∞ is the value of b for infinitely great volume, by determining, for each sphere of distance, the mean value of the portion cut off by another sphere. Later, from the consideration of three intersecting spheres, a method of determining ϵ_1 is given, according to which its value is found to be 0·0958. An elementary deduction of the equation of state for substances with extended and complex molecules is given, which shows that only at infinite dilution is b equal to four times the volume of the molecules, and that it diminishes with the volume. In the author's opinion, the differences between Boltzmann's results and his own arise from the conception of the problem by the former as one relating to *material points,* which cannot approach nearer than a certain limit, in which case the work done by "thermic pressure" does not appear. The author prefers his own view of the problem, and the direct treatment. W. E. T.

313. *An Exact Formula for the Variation of b with the Volume.* **J. D. van der Waals.** (Archives Néerlandaises, 6. pp. 47–54, 1901.)—By a more

rigorous discussion of the equations from which the author had previously [Arch. Néerl. (2), 4. 622, 1901] deduced for a substance with triatomic molecules in which two atoms have independent motions with respect to the centre of gravity of the system, the formula—

$$(b-b_0)/(v-b)=f\left\{1-(b'-b_0)^2/(b_l-b_0)^2\right\},$$

in which f has an approximately constant value lying between 1 and 2, he now shows how to deduce an exact formula. This is effected by the introduction of a quantity m of definite signification, which expresses how much the motion of one atom contributes to the increase of volume of the molecule: f is found to lie between 1 and 2, but to be no longer a constant, and the effect of this variability is especially sensible in the value of db/dv. Preliminary calculations authorise the conclusion that for CO_2 the value of m is not very different from 5/6. W. E. T.

314. *Adiabatics of a Gas.* **G. Moreau.** (Comptes Rendus, 133. pp. 732–735, Nov. 4, 1901.)—Assuming the characteristic to be $pv=p_0v_0(1+\alpha t+\beta t^2)$ and the isometric specific heat to be c_0+at, where t denotes C. temperature, we have at once for an adiabatic—

$$v^{B-1}(1+\alpha t+\beta t^2)\left\{(t-r)/(t-r')\right\}^A=\text{const.},$$

where r, r' are respectively $\left\{-\alpha\pm\sqrt{(\alpha^2-4\beta)}\right\}/2\beta$, and—

$$A\equiv(2\beta c_0-a\alpha)/a\sqrt{(\alpha^2-4\beta)},\qquad B\equiv1+2\beta p_0v_0/Ja,$$

J being Joule's equivalent. We thus get—

$$t=(\Theta r-kr')/(\Theta-k),$$

where $\Theta^A\equiv pv^B$ and k is a parameter characterising the adiabatic; and substitution in the characteristic of this expression for t gives the pv-equation of the adiabatic. [The above expressions are unreal unless $4\beta<\alpha^2$.] A simpler expression is also obtained by making two particular approximations; this can be valid only within a limited range. R. E. B.

315. *Characteristic for Slightly Compressible Gases.* **M. Reinganum.** (Ann. d. Physik, 6. 3. pp. 532–548, and 549–558, Nov., 1901.)—The first of these two papers is an extension of an earlier one [see Abstract No. 1291 (1901)], with the notation of which we have—

$$U=-Rbcv^{-1}(q-1)\left\{1/(q-4)+(c/T)/(2q-5)+(c/T)^2/2\,!(3q-6)\right.$$
$$\left.+(c/T)^3/3\,!(4q-7)+\ldots\right\}$$

if the attractive forces vary inversely as the qth power of the distance, where $q>4$, giving a characteristic of the form—

$$pv=RT+v^{-1}A(T).$$

In this case the virial of the attractive forces is $-\frac{1}{2}(q-1)U$.

In the second paper this characteristic is put into the approximately equivalent form—

$$p\left\{v+B(T)\right\}=RT,$$

and tested by application to Young's results for isopentane. The term B(T) seems to be justified, and A(T) is certainly not a *linear* function of T. R. E. B.

ELECTRICITY AND MAGNETISM.

THEORY AND ELECTROSTATICS.

316. *Rowland's Experiments on Electric Convection.* **Crémieu.** (Annal. Chim. Phys. 24. pp. 299-320, Nov., 1901.)—The negative results obtained in the two previous researches tended to throw doubt upon the existence of the electric field due to magnetic variations, and also upon the magnetic effect of electric convection. It became necessary to repeat Professor Rowland's work, eliminating certain causes of error. The result was entirely negative : Rowland's and Himstedt's deviations, when they are obtained, are not due to the magnetic field of the continuous current to which the electric convection would correspond, but are apparently traceable to purely electrostatic causes. A charged body in a field of magnetic variations is not subjected to any ponderomotive force. A rotating disk, under conditions in which one is sure that it carries with it all the electric charge communicated to it, does not produce, when this charge is varied, the effects of induction that a current would produce, transporting equal quantities of electricity and subject to variations of the same order. The same rotating disk charged in a constant manner does not produce the magnetic field of a conduction current carrying the same quantity of electricity. [See Abstracts Nos. 55 and 56 (1902).] A. D.

317. *Absence of Electric Displacement in Air moving in Magnetic Field.* **R. Blondlot.** (Comptes Rendus, 133. pp. 778-781, Nov. 11, 1901.)—The electrodynamical theories for bodies in movement, given by Hertz and Lorentz, both assert that when an insulating body is moved in a magnetic field at right angles to the lines of force, there is produced in it an electric displacement analogous to that which, according to Faraday and Maxwell, exists in the dielectric of a condenser. The two theories, however, give different values for the displacement ; that of Lorentz being equal to that of Hertz multiplied by $(K - K_0)/K$, where K is the specific inductive capacity of the dielectric in movement, and K_0 that of empty space. If air be the moving dielectric, Lorentz's value is zero, while that of Hertz is finite, and the author seeks to determine which is correct by experiment with air as the dielectric in motion. The invariable result of every experiment was to confirm the theory of Lorentz, as no displacement could be observed. W. C. H.

318. *Absence of Action of a Magnetic Field on a Mass of Air which is the Seat of a Displacement Current.* **R. Blondlot.** (Comptes Rendus, 133. pp. 848-850, Nov. 25, 1901.)—This paper deals with a correlative problem to that treated in the preceding Abstract. The author sets himself to find if, when a displacement current is set up in a body of air in a magnetic field at right angles to the lines of force, any action upon the air will be produced by the magnetic field. He arrives at the conclusion that there is no such action. Following the principle of equality of action and reaction, one might therefore conclude that a displacement current in air exercises no magnetic action, and that, in consequence, the charging current of a condenser is, from the magnetic point of view, an open current. This, however, would be the

negation of one of the principles on which Maxwell's theory is based; and if we desire to retain the theory, we must renounce the principle of reaction. Poincaré has already shown some incompatibilities between the principle of reaction and several of the electrodynamical theories, and, following him, the author does not see in this fact any reason to renounce beforehand those theories whose fruitfulness has been shown by the great discoveries to which they have led. W. C. H.

319. *Contact-Electricity and Surface-Tension.* **H. Pflaum.** (Phys. Zeitschr. 2. pp. 750–754, 1901. Journ. der Russ. Phys. Chem. Gesell. u. Nachr. des Technolog. Instituts.)—Electrisation is in all cases traceable in the last resort to the contact of dissimilar surfaces. Before contact, the two substances each present a condition of equilibrium between the ether of their inner volume and the surrounding ether; these conditions are disturbed upon contact, the conditions of the respective substances being approximated to one another. The condition of the ether within a substance is indicated by the refractive index; and (Coehn) bodies with high limiting values of the refractive index (small velocities of propagation of ether-waves) become positive upon contact with bodies of lower refractive indices. The condition of the ether within a substance is also indicated by the surface-tension; bodies with higher dielectric constants have also higher coefficients of capillarity. Liquids with higher coefficients of capillarity have also higher specific cohesions at the boiling-point and higher latent heats of their vapours. Obach found a relation between dielectric constants and latent heats on boiling. As a rule the greater the dielectric constant, the less the coefficient of thermal expansion. The dielectric and the capillary constant vary with temperature according to the same law. With solids the same association is indicated. Polished glass has a higher superficial tension than matt glass; and the former becomes positive, the latter negative on rubbing with leather or wool. Cork pressed upon metal or guttapercha so that it cannot dilate laterally has its superficial tension raised and becomes positively charged; if it be rubbed on, it is free to expand, and being warmed more than the metal, its superficial tension falls in proportion more than that of the metal, and the cork becomes negatively charged. Differences may thus be occasioned between the effects of gentle rubbing and of hard rubbing. Hesehus found a relation between the residual charge of a body and the expansion by heat, and traced the former to the mutual action between the interior condition and that of the surrounding ether. There is a complete parallelism between the variations of the dielectric constant and those of the superficial tension in various mixtures of ether ($C_2H_{10}O$) and chloroform, and also of alcohol and water, irregular though these variations be. A. D.

DISCHARGE AND OSCILLATIONS.

320. *Action of Magnetised Electrodes upon Electrical Discharge Phenomena in Rarefied Gases.* **C. E. S. Phillips.** (Roy. Soc., Phil. Trans. 197. pp. 135–150, Sept. 8, 1901. Abstract in Roy. Soc., Proc. 68. pp. 147–149, May 4, 1901.)—In the present paper the author describes further experiments illustrative of the effects produced by a magnetic field upon the distribution of ions within a highly evacuated space [see Abstracts Nos. 683 (1899) and 853 (1900)], and deals more particularly with the conditions necessary for the production of a luminous ring in rarefied gases and under the influence of electrostatic and magnetic forces. The cause of the luminous phenomenon is traced to the action of the magnetic field upon electrified gaseous particles within the rarefied space, and it is shown by experiment that the rate of change of the magnetic lines is an important factor. The ring itself is invariably negatively electrified, and its direction of rotation is that of the current induced in a loop of wire when the loop is suddenly moved up to a north magnetic pole—clockwise, looking through the loop at the pole. The outside of the glass bulb is always negatively electrified when the luminous ring appears in the interior, thus indicating the removal of a layer of positively electrified gas from the inner surface of the bulb by the action of the magnetic field. It is established by experiments that the loss of positive electrification from charged bodies in the rarefied gas is caused by the magnet, through the concentration of negative ions which occurs at the strongest part of the magnetic field immediately the electrodes are magnetised, and also that the luminosity of the ring itself is due largely to the collisions between the incoming streams of positive ions and this accumulation of negatively charged gas between the pointed ends of the electrodes. The direction of rotation of the ring forms a difficulty on the assumption that a rapidly moving ion is equivalent to a current along a flexible conductor, but the author accounts for it in the following manner: When the potential difference between the accumulation of negative ions at the centre of the bulb and the layer of electrified gas upon the inner surface of the glass is such that a shower of incoming positive ions occurs, and the luminous ring appears, the outer portion of the ring will be more positive than the surrounding negatively electrified cloud of gaseous particles. These will, therefore, be attracted inwards, and in that way give a rotatory motion to the luminous gas-mass in the direction actually observed. W. C. H.

321. *Electric Conductivity of Flames and Gases.* **A. de Hemptinne.** (Zeitschr. Phys. Chem. 39. pp. 345–352, Dec. 13, 1901.)—In determining the conductivity of gaseous mixtures at the moment of explosion, the author now uses an apparatus comprising two glass tubes, joined to a T, and a galvanometer, instead of the capillary electrometer previously employed. The galvanometer is found to be noticeably deflected in mixtures of H and O when the conditions favour the condensation of water vapour, *i.e.*, when air and dust can enter; the effect is much weaker when the apparatus communicates with a vacuum, and when the experiments are made at temperatures above 100° C. Hardly any deflection is observed in mixtures of H and Cl, and of CO and O. The author regards explosions as instantaneous flames.
H. B.

322. *Discharge Potential of Hydrogen at Mercury Kathodes.* **A. Coehn** and **E. Neumann.** (Zeitschr. Phys. Chem. 39. pp. 353–354, Dec. 13, 1901.)—The electrolytic generation of hydrogen is strictly reversible only with kathodes of platinised platinum, whilst with other metals a supertension is required (Caspari), which Ostwald has ascribed to the condition of the metallic surface. That condition should, however, only influence the formation of bubbles, not the discharge of hydrogen ions. Yet Dannenberg, waiting, like Caspari, not for the appearance of bubbles, but for the flow of a steady current, observed a high discharge potential with mercury kathodes, indicating that the nature of the metal, and not only its surface condition, is of influence. The authors dissolve concentrated HCl in alcohol

and find that the difference in the discharge potentials of hydrogen between platinum and mercury kathodes is substantially the same at − 85° C. (mercury frozen) as at + 18° C. H. B.

323. *Geissler Tubes in a Magnetic Field.* **H. Pellat.** (Comptes Rendus, 133. pp. 1200–1202, Dec. 23, 1901.)—When a long tube is laid through a magnetic field, at right angles to it; when the field is set up, not only is the anode light driven towards the strongest part of the field, but the stratifications seem to collect into the same region, new ones being formed at the anode, not at the kathode, the stratifications round which remain nearly undisturbed. The stratifications also become inclined to the axis of the tube in the field; they rise from the left hand to the right hand of an observer in the tube, looking down the field (towards the south pole), the plane of each stratification having rotated round the direction of the field. These phenomena of crowding and slanting occur in uniform or non-uniform, constant or variable fields; best with fields of from 90 to 170 c.g.s. units. If the tube be put through the holes in pole-pieces made use of in rotatory polarisation, when there is no field the tube is, between the pole-pieces, filled with the anode light; but when a field of from 2,500 to 3,000 c.g.s. units is set up the anode light shrinks to about one-third of its diameter, remaining axial. This is not easy to explain; the field is about 3 per cent. stronger along the axis between the holes than opposite the margins of the holes; and this would explain a concentration of magnetic oxygen molecules along the axis of the tube, but would not explain the similar behaviour of diamagnetic hydrogen. Does hydrogen become magnetic in a Geissler tube? A. D.

324. *Velocities of Ions in Gases.* **K. v. Wesendonck.** (Phys. Zeitschr, 3. pp. 45–46, Nov. 1, 1901.)—It is known that ozonised oxygen is a relatively bad conductor, especially if its conducting power is measured by allowing negative electricity to leak away through it. This, according to the author, is the cause why the ratio of the velocities of the ions is the same in air as in nitrogen, when the ions are produced by Röntgen rays or ultra-violet light, but is different if they are produced by a point discharge, the latter process producing ozone. R. S. W.

325. *Electrical Conductivity of Air and Salt Vapours.* **H. A. Wilson.** (Roy. Soc., Proc. 68. pp. 228–230, May 23, 1901 (Abstract); Roy. Soc., Phil. Trans. 197. pp. 415–441, Nov. 22, 1901.)—The object of the experiments described was to obtain information on the variation of the conductivity of air and of salt vapours with change of temperature, and on the maximum current which a definite amount of salt in the form of vapour can carry. The method employed was the following: A current of air containing a small amount of a salt solution in suspension in the form of spray was passed through a platinum tube heated in a gas furnace; this tube served as one electrode, and the other was fixed along its axis. The temperature of the tube was measured by means of a platinum platinum-rhodium thermo-couple, and the amount of salt passing through the tube was estimated by collecting the spray in a glass-wool plug. From the temperature variation of the conductivity the energy required to produce the ionisation can be calculated, and this compared with the energy required to ionise bodies in solutions. After a detailed description of the apparatus used, the results of observations on the variation of the current with the e.m.f., and the variation with the temperature of the current through air and through salt vapours are given.

The relation between the current and e.m.f. in air was found to depend very much on the direction of the current. When the outer electrode was negative the current attained a saturation value with an e.m.f. of about 200 volts, but when the outer tube was positive it increased rapidly with the current even with an e.m.f. of 800 volts.

With salt vapours the relation between the current and e.m.f. was not much affected by reversing the current. The current was always greater when the outer tube was negative, the reverse being the case with air alone. At low temperatures the current attained a saturation value, but above 1,000° C. it was found to increase more nearly proportionally to the e.m.f. The variation of the current at constant e.m.f. with the temperature for air was found to be approximately capable of being represented by a formula of the type $C = A\theta^n$, where C is the current, θ the absolute temperature, and A and n constants. The constant n depends on the e.m.f. used. With 240 volts it was 17, and with 40 volts 18. The current, therefore, does not begin suddenly when the temperature is raised, but always increases regularly with the temperature.

The energy required to ionise 1 gramme molecular weight of air was estimated by supposing that the fraction of the gas dissociated into ions is proportional to the current at small e.m.f.'s By means of the ordinary thermo-dynamical formula giving the variation of the dissociation with the temperature, the energy in question can then be obtained. The result for air is 60,000 calories between 1,000° and 1,300° C. This amount of energy is of the same order of magnitude as the energy set free when H and OH ions combine to form water in a solution. The current through a halogen salt vapour in presence of air and water reaches a maximum value near 900°, and then falls as the temperature rises. Near 1,100° it again rises rapidly with the temperature.

The energy required to ionise 1 gramme molecular weight of KI was found to be about 15,000 calories at about 800°. The maximum current carried by a definite amount of salt vapour was found to be nearly equal to the current required to electrolyse the same amount of salt in an aqueous solution.

These experiments were made with salts of potassium. Later experiments were carried out with various salts of the other alkali metals, and an account is given of these in an appendix to the paper. It was found that with many salts, on first applying the p.d., the current was often abnormally great for a short time and then settled down rapidly to a steady value, just as it does for air. The saturation current was found to be inversely proportional to the electrochemical equivalent of the salt. It appears from the experiments that Faraday's laws for the passage of electricity through liquids apply also to alkali salts in the state of vapour. This result supports the theory that the passage of electricity through salt vapours is a process very analogous to the electrolysis of salt solutions. J. J. S.

326. *Electric Vibrations.* **D. Mazzotto.** (N. Cimento, 2. pp. 178–187, Sept., 1901.)—A controversial paper in reply to M. Lamotte (Wied. Annal. 65. p. 92, 1898.)—The author maintains that his methods are exact and are confirmed by Lamotte's own results. [See Abstracts Nos. 170 (1898) and 67 (1902).] A. D.

327. *Theory of Hertzian Oscillators.* **H. Poincaré.** (Écl. Électr. 29. pp. 305–307, Nov. 30, 1901.)—A paper by K. R. Johnson [see Abstract

No. 1927 (1901)] criticised by the author. The experiments of Décombe and Tissot, showing that the spark discharge can be analysed by a turning mirror, are totally at variance with his theory of the exciter. Still greater exception is taken to his theory of the resonator, for according to the calculations of Johnson the resonator responds equally well whatever the mutual induction of the sender and receiver, *i.e.*, whatever the distance between them. The author considers that Johnson's results are obtained partly because he fails to take account of displacement currents. P. E. S.

328. *Loaded Conductors.* **M. I. Pupin.** (Elect. World and Engineer, 38. pp. 587–588, Oct. 12, 1901.)—This is a note upon the author's original paper on the behaviour of loaded conductors or circuits when used for telephonic transmission [see Abstract No. 1381 (1899)]. Numerical cases are taken, and the results exhibited graphically as regards attenuation constants and wave-lengths, as the number of loads per wave-length is changed through a considerable range. It is thus shown that loaded conductors act, to a close approximation, like their corresponding uniform conductors, when the number of loads is sixteen per wave-length. When, on the other hand, the number of loads per wave-length is reduced to four, the resemblance between the two conductors is very slight. The attenuation constant is very high for only four loads per wave-length, and may be anything if the number of loads is reduced to between 4 and π. Also the wave-lengths of the loaded conductor is a definite quantity only as long as the conductor is properly loaded. On a poorly loaded conductor the wave-length may be either smaller or greater than the wave-length on the corresponding uniform conductor. E. H. B.

ELECTRICAL PROPERTIES AND INSTRUMENTS.

329. *Electric Conductivity of Red Nitric Oxide Vapours.* **A. Pochettino.** (Accad. Lincei, Atti, 10. pp. 202–207, Nov. 3, 1901.)—Hempel found (1866) that red N_2O_4 vapours interposed in the path of the spark of a frictional machine released all tension, so that no spark passed. These vapours are at ordinary temperatures partly dissociated into NO_2. Other observers have found that N_2O_4 vapours have not a high conductivity at any temperature (J. J. Thomson, de Hemptinne); the conductivity as deduced from the resistance to dispersion of charge is about the same as that of ordinary air. The author finds that the sparking distance is less in these vapours than it is in air, and for a discharge between a point and a plane the vapours are a better insulator than air. The effect observed by Hempel must be due to some secondary cause. A. D.

330. *Electric Properties of Copper-Cobalt Alloys.* **G. Reichardt.** (Ann. d. Physik, 6. 4. pp. 832–855, Dec., 1901.)—Experiments conducted in the Reichsanstalt on alloys supplied by Basse and Selve in rods 2 cm. in diameter. Alloys with up to 40 per cent. of Co can be cut with the circular saw and drawn out to wire; richer cobalt alloys could only be cut on a planing machine. The analyses were made by Funk and Dietz; the alloys contained traces of Fe and Ni (the Co was not quite free from Cu), and were not very homogeneous. The resistance of the wires decreases on continued heating for 48 hours up to 160° C.; this applies also to manganin and to the Kulmiz resistances, not to constantan. The specific resistance increases

with the proportion of Co, very rapidly for alloys containing either little or very much cobalt. The temperature coefficient is a linear function of the temperature. In two alloys with more than 8 per cent. of Co the temperature coefficient and resistance rise simultaneously, contrary to most other alloys. The thermoelectric force increases first up to 8 per cent. of Co, then sinks, and rises again above 90 per cent. of Co. Thus slight admixtures of either metal to the other have a very marked effect throughout; as regards the medium percentages, the ascending and descending curves (starting from Co or Cu respectively) do not coincide. The effect of cobalt in copper alloys is about as strong as that of manganese, and three times as strong as that of nickel, from which cobalt differs in electric and magnetic, as in many other properties; the cobalt-copper alloys remain magnetisable up to red glow, the nickel-copper alloys are not magnetic. Only the alloys containing 1 or 2 per cent. of Co appear to be of practical value as thermo-couples. H. B.

331. *Measurement of Self-Inductance.* **W. Duane.** (Phys. Rev. 13. pp. 250–252, Oct., 1901.)—If a coil is wound in two parts, with mutual induction M and self-inductances L_1 and L_2, the self-inductance of the whole is $L' = L_1 + 2M + L_2$ when the current flows in the same direction, and $L'' = L_1 - 2M + L_2$ when it flows in opposite directions, through both coils in series. The ratio $L'/L'' = A$ is found by comparing each with a third self-inductance L. Then M is measured by any usual method (*e.g.*, the earth-inductor and ballistic galvanometer, &c.). Then $L' = 4MA/(A-1)$ and $L'' = 4M/(A-1)$. If the coil be not so wound, the above method can be applied by conjoining another coil with it, maintaining a uniform distance between them, so as to keep the value of M constant. A. D.

332. *Wire Bridges for Elementary Students.* **J. Pernet.** (Archives Néerlandaises, 6. pp. 377–381, 1901.)—The author begins by recommending the use of simple apparatus in which the corrections to be applied and the degree of accuracy attainable can be arrived at. Not only for cheapness but also as having great instructional value is this advisable. Illustrations of the types of experiment to be chosen and to be avoided are drawn from thermometer calibration and from the wire bridge calibration methods of Strouhal and Barus, and Thiesen. A form of wire bridge illustrative of the previous argument is then described. The wire (whose material has as small a temperature coefficient as possible) is 510 cm. long. It is arranged in straight pieces and spirals on a board 2 metres long as follows:—10 cm. straight, 90 spiral, 10 straight, 90 spiral, 110 straight, 90 spiral, 10 straight, 90 spiral, 10 straight. The central piece, 110 cm. long, is the part where the measurements are taken, and it is accordingly provided with a subdivided scale. J. W. P.

333. *Wehnelt Interrupter.* **M. A. Codd.** (Elect. Rev. 49. pp. 787–789, Nov. 15, 1901.)—The paper describes several experiments made with the Wehnelt interrupter. As the voltage on the primary coil is increased the current and the spark-length increase up to a maximum and then diminish, but if two breaks be used in series they increase continually within the limits of voltage employed (0 to 200 volts). With two breaks the spark-length is considerably greater than with one. The length of spark, and the effect of using two breaks in series, depends upon the self-induction of the primary coil; the best value of the self-induction depends on the current, the frequency, and the voltage. Any number of breaks can be worked in parallel, provided the surface of platinum exposed in each break be the

same, and the strength of acid the same. The author found the break to cease working at a temperature of 75° C., but if kept cool by a water-jacket, it continued to work well for an indefinite time. He describes and gives an illustration of a form of break found satisfactory in use. G. H. B.

ALTERNATING CURRENTS AND MAGNETISM.

334. *Action of Direct-current Armatures on Alternating Currents.* **M. Latour.** (Écl. Électr. 29. pp. 294–300, Nov. 23, 1901.)—The author gives a theory of the properties which he has discovered of direct-current armatures when traversed by alternating currents. These properties were called in question by Leblanc [see Abstract No. 80 (1902)], who, from *à priori* considerations, gave reasons for doubting them. The author quotes a letter from Boucherot, who states that he has experimentally proved that the impedance between two neighbouring brushes pressing on the commutator, when connected to a polyphase system, is a function of the speed of the armature. He took the drum-wound armature of a four-pole direct-current dynamo and placed it in the stator field of an induction motor, the windings of the stator being left open-circuited. With direct-currents the resistance between No. 1 and No. 3 brush, or between No. 2 and No. 4 brush, was 1·8 ohms. The brushes were then connected to a two-phase system of frequency 25. The impedance between the brushes was found to vary from 15 ohms at rest to about 2 ohms at synchronism, and at higher speeds it increased. At speeds greater than synchronism the armature acted like a condenser. If the armature were rotated the other way, the impedance continually increased as the speed increased. He also proved experimentally that the impedance did not vary at all as the speed altered, if only single-phase alternating currents were used. Latour gives a complete theoretical discussion of this property, and mentions several practical uses that can be made of his discovery, as *e.g.*, constructing self-exciting polyphasers, &c., most of which are mentioned in his patent applied for on Dec. 13, 1900. A. R.

335. *Properties of Direct-current Armatures Traversed by Alternating Currents.* **A. Heyland.** (Écl. Électr. 29. pp. 328–329, Nov. 30, 1901.)—Leblanc in his paper [see Abstract No. 80 (1902)], disputing the alleged properties of direct-current armatures traversed by alternating currents, attributes the statement of them to the author. Heyland points out that in his motor [see Abstract No. 2475 (1901)] the commutator bars are all connected together by non-inductive coils of appreciable resistance. He agrees in general with Leblanc's conclusions. A. R.

336. *Rectifier.* **F. J. Koch, Jr.** (Elektrotechn. Zeitschr. 22. pp. 853–854, Oct. 10, 1901.)—When a rectified current is used to charge a battery, current passes into the battery only so long as the e.m.f. of the rectified current is greater than that of the battery, and consequently in each current impulse (corresponding to each half cycle in the alternating current) there is a period during which the battery receives no charge, and two points where the opposing e.m.f.'s are equal and the current is zero. The author, in his device, breaks the circuit at one of these points and closes it again at another. This he does by a polarised relay with two opposing shunt windings, one taking the alternate pressure and the other the battery pressure; the relay is arranged so as to close the circuit only when the alternate pressure is of the same sign as and greater than the battery pressure. The self-induction of the relay windings and the armature inertia, however, have the effect of retarding the moments of opening and closing, and the author to remedy this includes in series a condenser and a coil with adjustable iron core, by which the phase of the current in the relay windings can be regulated so that the circuit is opened at the proper moment. If the battery pressure be nearly equal to the maximum alternate-current pressure, the period between closing and opening the circuit will be far shorter than that between opening and closing, and too short for proper working. On this account the author inserts a choking coil in the main circuit, which has the effect of spreading out the current curve, making the time of closed circuit longer. A small apparatus for rectifying 20 amperes at 120 volts and 50 ∿ was constructed, and worked quite sparklessly. G. H. B.

337. *Permeameter.* **F. G. Baily.** (Electrician, 48. pp. 172–174, Nov. 22, 1901. Paper read before the British Association at Glasgow.)—This permeameter is designed to read the permeability directly, without measurement of B or H. The apparatus consists of two long magnetising coils side by side, in which two strips of the specimen are placed. The magnetic circuit is completed by two short blocks of soft iron at the ends, provided with clamps. One of the blocks is divided across the direction of the lines of force, and a gap is made by the insertion of a thin brass sheet. Above this gap is pivoted on a needle-point a system of two vertical magnets with reversed poles, forming an astatic combination. The lower pair of poles lies close to the iron pole-pieces, and is affected by the leakage magnetic field; the force acting on it is therefore proportional to the induction in the circuit. Round the upper pair of poles is a coil which carries the magnetising current. The needle system has a pointer capable of a small motion between two stops; in its zero position the magnet poles lie in the plane of the air-gap. The coil round the upper poles can be moved about a vertical axis, so as to vary the force exerted in the poles from zero to a maximum. Its position is read on a scale. This coil is moved till the needle system comes to zero, when there is a definite relation, depending on the constants of the apparatus, between the magnetising current and the induction. The scale can be given an empirical graduation to read μ directly. The author points out the sources of error in the apparatus, which are in general negligible. G. H. B.

338. *Measurement of Magnetic Field Strength by the Quadrant Electrometer, and the Susceptibility of Water.* **J. Koenigsberger.** (Ann. d. Physik, 6. 3. pp. 506–519, Nov., 1901.)—The author first shows that the change of field strength through a coil is proportional to the time-integral of the pressure in an open circuit as well as to that of the current in a closed circuit, and consequently that an electrostatic voltmeter is equally well adapted for measurements of field strength as is the ballistic galvanometer. The quantities which must be determined for the measurement are the constant, the period and the logarithmic decrement of the electrometer, and the number of turns and area of the induction coil. The advantage of the electrometer over the ballistic galvanometer are its freedom from magnetic disturbances, and the greater accuracy with which its constant can be determined in absolute units by use of a standard cell, than can that of a galvanometer by measurement of current and resistance, or of horizontal intensity. Further, in the case of a d'Arsonval galvanometer, its high damping precludes an accurate determination of the

period. The electrometer employed was that designed by Himstedt (Wied. Ann. 50. p. 758, 1893), the needle being charged by 100 Cu-Zn cells in magnesium sulphate. Its constant was 0·004 volt per mm. at 2,800 mm. scale-distance. All the constants mentioned above could be determined with an accuracy of ⅓ in 1,000, while readings showed a probable error of 1 in 1,000, due probably to variation in the magnetising current.

The author then measured the susceptibilities of iron chloride solution and of water by Quincke's method. The different values obtained by other experimenters he attributes to errors in the measurement of the field strength, which he believes to be greatly reduced by the use of the electrometer. He found the susceptibility of water, compared with that of air, to be at 22° C. $0{\cdot}804 \times 10^{-6}$, and compared with vacuum, $0{\cdot}781 \times 10^{-6}$. That of iron chloride solution, compared with vacuum, was, at 18° C. $\{87{\cdot}9 \,.\, p - 0{\cdot}781\,(1 - p)\}\,10^{-6}$, where p is the percentage of iron chloride. G. H. B.

339. *The Law of Magnetic Induction.* **E. Müllendorff.** (Elektrotechn. Zeitschr. 22. pp. 925–928, Nov. 7, 1901.)—It is shown that a formula connecting magnetising power and magnetic induction can be obtained. This takes the form—

$$B = a\left(1 - \frac{1}{\sqrt{1 + bM^2}}\right) + cM,$$

where B = number of lines per sq. cm., M = magnetising power in ampere-turns per cm., and a, b, c are constants depending on the material. These are given for the two cases below :—

	a	*b*	*c*
Wrought iron	16,870	0·1	3·2
Cast iron	6,500	0·3	25

The agreement between the observed and calculated values is fairly close. W. W. H. G.

340. *Variations of Terrestrial Magnetism.* **W. van Bemmelen.** (Archives Néerlandaises, 6. pp. 382–384, 1901.)—A new series of fluctuations in the horizontal component of the earth's magnetism is here pointed out. The observations are taken at Batavia, and compare with similar ones at Zi-Ka-Wei and at Karang-Sago. The amplitude is only of the order of 10^{-4} of the horizontal component, and the period a few minutes. The duration of this pulsation varies from several minutes to several hours. The observations are admitted to be still insufficient ; but an explanation is suggested in the electric currents which, according to Schmidt, are circulating round the globe in the atmosphere and causing the polar auroræ. Periodic fluctuations in these currents are suggested as the cause of the magnetic pulsations here observed. J. W. P.

REFERENCES.

341. *Application of Grassmann's "Ausdehnungslehre" to Alternating-Current Problems.* **F. Punga.** (Zeitschr. Elektrotechn., Wien, 19. pp. 505–508, Oct. 20, and pp. 516–520, Oct. 27, 1901.)—The author gives an account of the topographic method of solving alternating-current problems, deducing it from Grassmann's *Ausdehnungslehre.* A. H.

342. *Application of Lagrange's Equations to Electrodynamics.* **E. Carvallo.** (Comptes Rendus, 133. pp. 924–927, Dec. 2, 1901.)

CHEMICAL PHYSICS AND ELECTRO-CHEMISTRY.

343. *Deliquescent and Hygroscopic Salts of Copper, Cobalt, and Nickel.* **W. N. Hartley.** (Roy. Dublin Soc., Trans. 7. pp. 313–320, July, 1901.)—The experiments described were made with the object of ascertaining the conditions of equilibrium under ordinary atmospheric changes, which govern the formation of hydrates of the hygroscopic and deliquescent haloid salts of copper, cobalt, and nickel. The observations appear to confirm the conclusions drawn by the author from his previous experiments [see Abstract No. 161 (1901)], and show that the bromides are more deliquescent than chlorides, and the iodide than the bromides; also that the most stable liquid hydrates are those of nickel iodide, with 23 and 21 molecules of water, while next in order are the cobalt bromide and nickel bromide, with 18 molecules; cobalt chloride, with 11 molecules; cupric bromide with 4 molecules; and cupric chloride with 3 molecules of water. The chemical relationship of the absorbed water to the salt is shown by the fact that the three metals do not differ largely in atomic mass, the differences in the molecular mass of each of the salts being principally due to the atomic masses of the halogen elements, which differ widely. It appears that it is not any one constituent of the salt, but the salt molecule as a whole which combines with the water, and that the attraction of the salt for water is independent of the molecular mass of the salt. That is, it is a true chemical combination, dependent for its formation on the chemical property of the whole molecule of the salt, and not upon that of any one or other of its constituents. These results have a practical bearing on the preparation of the crystallised compounds, the conditions under which they may be produced being now known. J. J. S.

344. *Pressure as the Supplement of Temperature in Ignition Phenomena.* **W. Spring.** (Archives Néerlandaises, 6. pp. 257–261, 1901.)—On slowly compressing a mixture of cuprous oxide and sulphur the following reaction takes place *explosively* :—

$$2Cu_2O + 3S = 2Cu_2S + SO_2:$$

Thus in this case pressure has had a similar effect to temperature in increasing the speed of an exothermic reaction. [See also Abstract No. 769 (1901).]

F. G. D.

345. *Vapour-Tensions of Binary and Ternary Mixtures of Liquids.* **F. A. H. Schreinemakers.** (Archives Néerlandaises, 4. pp. 346–369, 1901.)—This paper opens with an account of the author's previous experimental and theoretical work on the systems water-phenol; water-aniline; water-phenol-aniline [see Abstract No. 532 (1901)]. This is followed by a description and sketch of the apparatus employed in determining the vapour pressures and and phase-compositions of polyphase liquid systems, and a full theoretical discussion of the data obtained for the three systems already mentioned.

F. G. D.

346. *Phase-law Study of Phosphonium Chloride.* **G. Tammann.** (Archives Néerlandaises, 6. pp. 244–256, 1901.)—Measurements giving the *p-t* curves for

the following systems: crystals, vapour; crystals, liquid; liquid vapour. The volume-changes on melting and the corresponding heats were also measured. The liquid-vapour system was followed up to the critical point. A peculiarity of the system solid-liquid in this case is that the corresponding *p-t* curve extends into the *hypercritical region, i.e.,* the solid and liquid can coexist at high pressures at temperatures lying far above the critical point of the system liquid-vapour. F. G. D.

347. *Remarks on a paper of Schükarew's.* **J. J. van Laar.** (Zeitschr. Phys. Chem. 39. pp. 342–344, Dec. 13, 1901.)—In a recent paper [see Abstract No. 114, 1902] Schükarew had deduced thermodynamically a new law of partition between two phases. In the present note van Laar points out that Schükarew's reasoning is entirely fallacious. F. G. D.

348. *Catalysis in Concentrated Solutions.* **J. M. Crafts.** (Chem. News, 84. pp. 205–207, Oct. 25, and pp. 213–215, Nov. 1, 1901. From the Amer. Chem. Soc., Journ. 23, No. 4.)—The hydrolysis of 1:3:4 metaxylene-sulphonic acid by means of hydrochloric or sulphuric acid proceeds at 100° with a velocity which is convenient for measurement; nitric acid, however, has hardly any hydrolysing action, and was not further studied. In the case of catalytic actions, such as the inversion of sugar, which proceed in dilute solution, the acid used becomes proportionately less active as its concentration increases, and the effect produced is usually regarded as due to the hydrogen ions. In the hydrolysis of metaxylene-sulphonic acid, however, a 38 per cent. hydrochloric acid acts with thirty-five times greater rapidity than a 19 per cent. acid, and the velocity is further increased more than threefold by the addition of half its weight of zinc chloride to the 38 per cent. acid. In explanation of this difference it is pointed out that the sugars and esters which have previously been investigated are not themselves capable of any marked degree of dissociation, whilst the sulphonic acids are dissociated to nearly the same degree as the strongest acids; if hydrolysis takes place only upon undissociated molecules, the remarkable increase of velocity due to the use of concentrated acids and to the addition of zinc chloride may be owing to the prevention of the dissociation of the catalysed acid, whilst that of the catalysor subsists to a certain degree. In two preliminary experiments evidence was obtained that the sulphonic acids are capable to some extent of bringing about their own hydrolysis. Further experiments are in progress. T. M. L.

349. *Crystallography of the Double Selenates,* $R_2Mg(SeO_4)_2, 6H_2O$. **A. E. Tutton.** (Roy. Soc., Phil. Trans. 197. pp. 255–284, Oct. 26, 1901.)—The author gives the results of an examination of the magnesium double selenates of the above composition, R representing K, Rb or Cs. Comparison is made with the results obtained for the corresponding zinc double selenates previously examined [see Abstract No. 170 (1901)]. T. H. P.

350. *Polymerisation of Inorganic Chloro-anhydrides.* **G. Ciamician.** (Accad. Lincei, Atti, 10. pp. 221–226, Nov. 17, 1901.)—The fact that the molecular weights obtained by the ebullioscopic method for certain inorganic chloro-anhydrides seem to indicate polymerisation of these compounds, has been explained by Oddo as due to the volatility of the dissolved substances at the temperature of the boiling solution. On determining the value of the ratio a of the concentrations of phosphorus oxychloride in the vapour

given off from a benzene solution, and in the solution itself, and allowing for the volatilisation by multiplying the observed molecular weight by $(1-\alpha)$, Oddo found that the numbers obtained were still greater than the true molecular weight. On repeating these experiments, however, the author finds for α a mean value of 0·515, Oddo's numbers being 0·27, 0·31 and 0·27; correcting by means of the value 0·515, the experimental molecular weights agree well with the normal value. T. H. P.

351. *Law of Action of Invertin.* **V. Henri.** (Zeitschr. Phys. Chem. 39. pp. 194–216, Dec. 5, 1901.)—The author has made an extensive series of experiments on the velocity of inversion of cane-sugar by invertin. Instead of the equation $\frac{dx}{dt}=k(a-x)$, he proposes the equation—

$$\frac{dx}{dt}=k_1\left(i+\epsilon\frac{x}{a}\right)(a-x),$$

to express the velocity, where $x=$ amt. of invert sugar produced at any moment, $a=$ original amt. of cane-sugar, k_1, $\epsilon=$ constants. Experience shows that in the present case ϵ has very nearly the value unity. The integrated expression, when $\epsilon=1$, is $2k_1=\frac{1}{t}\log\frac{a+x}{a-x}$. This agrees fairly well with the experimental results. The *duration* of the action has no influence on the activity of the diastase, *i.e.*, the velocity at any moment is only determined by x and a. The "constant" k_1 varies with a, diminishing as a increases, but k_1a is not constant (as Duclaux assumed). F. G. D.

352. *Determination of Molecular Weights of Substances in Dilute Solutions.* **G. Guglielmo.** (Accad. Lincei, Atti, 10. pp. 232–239, Nov. 17, 1901.)—All those methods used in hygrometry to determine the tension of the aqueous vapour of the air and the relation between this tension and that of saturated vapour at the same temperature, can be employed to measure the tensions of vapours in contact with (1) a solution, and (2) the pure solvent, from which the molecular weight of the dissolved substance can be deduced. The author describes three different methods of working, in all of which only very simple apparatus is required. In the first method, a layer about 1 cm. deep of the solution is placed in a small flask furnished with a three-holed stopper through which pass two thermometers reaching to within 1 cm. of the liquid, the bulb of one being surrounded by two or three thicknesses of filter paper fastened to the thermometer; through the third hole passes a glass rod with its lower end bent horizontal for the purpose of stirring the liquid. The measurement is made by raising the stopper for a moment, and by means of a pipette, thoroughly moistening the covered thermometer bulb with the solvent; the stopper being replaced, the temperatures of the two thermometers soon become constant and are read off. Then $M=Cp/(t-t_1)$, C having the value $BF/(A/H+h)$, where M is the molecular weight of the dissolved substance, p the weight of the latter per 100 parts of the solvent, t and t_1 the temperatures of the uncovered and covered thermometer bulbs, F the vapour pressure of the solvent at $t°$, H the atmospheric pressure, h the variation of the latter for 1°, and A, B, and C constants. The value of C may be calculated from the expression given above, or it may be determined experimentally by means of a solution of a compound of known molecular weight. In the second method no thermometer is needed, the rate of evaporation, and hence the rate of cooling, of a rod or tube surrounded

at its lower part by filter paper and moistened with the solvent being measured by its loss in weight in a certain time when placed in the flask employed in the previous method. The last method also makes use of a wide-necked flask fitted with a perforated stopper which carries a wide nickeled tube closed at the bottom and containing a little of the solvent; the top of this tube is closed by a trebly-bored stopper through which pass a thermometer dipping in the liquid, a tube also dipping in the liquid and drawn out to a fine orifice at the bottom, and another shorter tube open at both ends and not reaching the solvent. Air is caused to bubble through the solvent by means of the drawn-out tube, the evaporation thus produced serving to cool the nickeled tube, which acts as it does in Regnault's hygrometer. The author gives the necessary details to be attended to in the practical working of these three methods. T. H. P.

353. *Position of the Rare Earth Metals among the Elements.* **B. D. Steele.** (Chem. News, 84. pp. 245–247, Nov. 22, 1901.)—In the ordinary periodic grouping of the elements, there are fifteen blank spaces between cerium (at. wt. 140) and tantalum (183). The metals of the rare earths have atomic weights which would place them between these two elements, but their properties seem to indicate that they belong to the third group. The author assumes that these metals form an inter-periodic group which possesses certain analogies with the true groups of the periodic system. The two first groups of the classification comprise elements showing a distinct periodic variation in all their properties, and these are followed by two groups each containing seventeen elements, three of which do not exhibit a periodicity in their properties. On proceeding to the elements with higher atomic weights, the number of these inter-periodic elements increases, and it is among these that the author places the rare earth metals. Next comes a periodic group in which only thorium and uranium are known, and to which possibly radium and polonium belong. That there is no regular gradation in properties of iron, nickel, and cobalt, of the platinum metals, and of the rare earth metals, may be seen from the molecular volume curve of the typical oxides and from the curve of atomic volumes of the elements. In order to calculate some of these latter which are not known, the author starts from the fact that the atomic volume of oxygen in combination with the alkali and alkaline earth metals is negative, whilst in the oxides of silicon, phosphorus, sulphur, and chlorine it is positive, and in those of the intervening elements is zero. Further, in the oxides of zirconium, lanthanum, cerium, and thorium the atomic volume of oxygen has the values 0, 1, 2, and 2 respectively; the author assumes that in the rare earth metals it approximates to 1·5. On this basis it is found that these metals have small atomic volumes—a fact which is in agreement with (1) the observation of Abegg and Bodländer that small atomic volumes are possessed by elements with low electro-affinity, and (2) that of Stefan Meyer that this property is usually found with paramagnetic elements.
T. H. P.

354. *Thermodynamics of Unsaturated Solutions.* **N. Schiller.** (Archives Néerlandaises, 6. pp. 497–549, 1901.)—This paper contains a treatment of unsaturated solutions similar to that previously applied to saturated solutions [see Abstract No. 1735 (1901)]. In particular, when only the solvent can evaporate, if σ is the specific volume of the pure solvent under pressure π, and σ' is the partial specific volume of the same solvent when a constituent of a solution of concentration ζ under external pressure $\pi + q$, q being the corresponding osmotic pressure, the relation $\sigma' = \sigma(1 + \lambda_1 \zeta)$, λ_1 depending only on π and the temperature, is shown to be true independently of any law of elastic compression, and of the form of the relation between the osmotic pressure and the concentration of the solution. W. E. T.

355. *Interaction of Calcium Ammonium, and of Lithium Ammonium, with Ammonium Chloride.* **H. Moissan.** (Comptes Rendus, 133. pp. 715–717, Nov. 4, 1901.)—Calcium ammonium, $Ca(NH_3)_4$, and lithium ammonium, $Li(NH_3)$, both react with ammonium chloride dissolved in liquefied ammonia at a temperature of −80°; but, under these conditions, ammonia and hydrogen are liberated, and the group (NH_4), cannot be isolated. D. H. J.

356. *Ammonium Amalgam.* **H. Moissan.** (Comptes Rendus, 133. pp. 803–808, Nov. 18, 1901.)—By the action of ammonium chloride or bromide in liquid ammonia on sodium amalgam, a metallic mass is obtained in which hydrogen and ammonia are present in stable combination at −89°; this metallic mass, on decomposing at the ordinary temperature in the absence of moisture, expands to thirty times its volume, and gives off two volumes of ammonia to one volume of hydrogen. D. H. J.

357. *Action of Various Metals Dissolved in Liquefied Ammonia on Hydrogen Sulphide.* **H. Moissan.** (Comptes Rendus, 133. pp. 771–774, Nov. 11, 1901.)—The author endeavours to obtain ammonium, NH_4, by the action of solutions of calcium and lithium in liquefied ammonia, on liquefied hydrogen sulphide. In each case the ammonium, if produced, dissociates at once into ammonia and hydrogen. W. C. B.

358. *Absorption Spectrum of Colloid Ferric Hydrate.* **B. E. Moore.** (Phys. Rev. 13. pp. 246–249, Oct., 1901.)—The author pointed out in a previous article [Abstract No. 1359 (1901)] that the final product of hydrolysis of ferric chloride could be compared with Graham's colloid ferric hydrate. On comparison, however, of the absorption spectra of the two solutions, he found that the curves for equal concentrations were quite different in character. In explanation of this, he adopts the view that the colloid ferric hydrate solution contains appreciable quantities of the crystalloid hydrate. E. C. C. B.

359. *Tin-Aluminium Alloys.* **L. Guillet.** (Comptes Rendus, 133. pp. 935–937, Dec. 2, 1901.)—By heating mixtures of granulated aluminium and stannic acid varying in composition between those corresponding with the formulæ Al_4Sn and $AlSn_5$, the author has isolated two compounds of the compositions Al_4Sn and $AlSn$, both of which form well-shaped lamellar crystals. T. H. P.

360. *Freezing-point Curves of Binary Alloys.* **A. W. Kapp.** (Ann. d. Physik, 6. 4. pp. 754–773, Dec., 1901. Extract from Dissertation, Königsberg, 1901.)—The author prepared alloys of Bi-Sn, Bi-Pb, Bi-Cd, Sn-Pb, Sn-Cd, Pb-Cd, by melting mixtures of varying proportions, increasing in steps of 10 per cent., in an iron crucible with thin walls, generally under a layer of charcoal, allowing the mass to cool slowly by placing the crucible within a block of wood lined with asbestos. He observed the freezing-points and the number of seconds during which the mass cooled by one scale division of about 6° C. Attention is drawn to the similar behaviour of mixtures of organic compounds. The author inclines to Ostwald's view, according to which either metal acts as solvent for the other, causing a depression of the freezing-point,

The fact that the lower fixed point has its highest value for the eutectic alloy he explains with Nernst by assuming that we observe an apparent freezing-point at which the heat lost by radiation is equal to the heat rendered free. As regards the composition of his alloys, as derived from his complete freezing-point curves, he does not agree with Guthrie. Rudberg and Guthrie are the chief authorities quoted. H. B.

361. *Solvent and Dissociating Properties of Liquid Cyanogen and of Hydrocyanic Acid.* **M. Centnerszwer.** (Zeitschr. Phys. Chem. 39. pp. 217–224, Dec. 5, 1901. Paper read before the Russischen Physiko-chemischen Gesell., Sept. 13, 1901.)—The author repeats and amplifies the work of Gore (Roy. Soc., Proc. 20. 67, 1872) on the solvent powers of liquid cyanogen; the latter came to the conclusion that this substance was inert, and in most cases did not act as a solvent. It has been shown that various substances, amongst them the organic cyanogen derivatives, are able to dissolve salts, especially the iodides, and that the bodies dissolved are partially ionised. For these reasons it is important to examine the solvent properties of liquid cyanogen.

Fifty-four substances were tested, including organic and inorganic chlorides, bromides, iodides, and cyanides; picric acid, trichloracetic acid, quinoline, di-phenyl-methane toluene and benzil. The only compounds found to dissolve were arsenic trichloride and tribromide, tin tetrachloride and tetrabromide; picric, trichloracetic, and tribromacetic acids; quinoline, acetonitrile, toluene, triphenyl-methane and benzil; antimony trichloride was also slightly soluble.

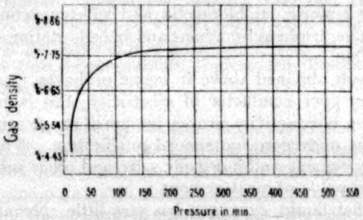
From the result obtained above it seems probable that liquid cyanogen will prove a very poor conductor of electricity; this is fully borne out by experiment, as the conductivity proves too small for measurement, although the cyanogen has undergone no special purification. The conductivity, in presence of many organic and inorganic salts, and other substances also, is so small as to be incapable of measurement.

This proves that liquid cyanogen has very little solvent, and no ionising powers. According to Dutoit and Aston's hypothesis (Compt. Rend. 125. 240, 1897), only those solvents which are themselves associated show ionising power; from this the author concludes that liquid cyanogen molecules may have a simpler constitution than the gaseous molecules, and perhaps have the formula CN instead of C_2N_2. Other facts, notably its low boiling-point, tend in the same direction.

The second part of the paper consists of a research on the properties of hydrocyanic acid as a solvent. It has been shown that the dielectric constant for this substance is greater than that for water, and is only exceeded by that for hydrogen peroxide [see Schlundt, Abstract No. 1358 (1901)]; this, taken in conjunction with the fact that HCN is the lowest member of the nitrile series, renders it probable that it will prove an ionising solvent. This is fully borne out by experiment, as many salts dissolve easily in the liquid. The conductivity of pure hydrocyanic was found to vary, but the lowest value obtained was $0{\cdot}496 \times 10^{-5}$ reciprocal Siemens units. Tables of the molecular conductivities of potassium iodide and trimethyl sulphine iodide in hydrocyanic acid are given; and the values obtained show that these solutions conduct approximately four times as well as solutions of the same salts in water, at the same concentration and temperature. The conductivity is almost as large as that of aqueous solutions of the halogen acids at 25° C. These measurements show that hydrocyanic acid has a greater dissociating power than water; and this, taken in conjunction with the high value of the dielectric constant, is another instance in support of the rule of Thomson and Nernst, as to the parallelism of these properties. W. C. B.

362. *Number of Ions in Metallammonium Compounds.* **E. Petersen.** (Zeitschr. Phys. Chem. 39. pp. 249–252, Dec. 5, 1901.)—A polemical paper, in which the author upholds his objections against Werner and Herty's method [see Abstract No. 127 (1902)] of determining the type of a salt; he states that the number of ions formed by a salt cannot be derived from the conductivity at a certain dilution. The author's measurements agree with those of Werner and Herty except for platinum-ammonia chloride, in which case the author explains the deviations as due to the non-identity of the two compounds examined. T. H. P.

363. *Dissociation of the Sulphur Molecule S_8.* **H. Biltz.** (Deutsch. Chem. Gesell., Ber. 34. pp. 2490–2495, Sept. 28, 1901.)—It was shown by Dumas that at a temperature near the boiling-point, the density of sulphur corresponded nearly with that required for the formula S_6, whilst Deville and Troost subsequently showed that above 860° values are obtained corresponding with the formula S_2. More recently cryoscopic and ebullioscopic methods have established the formula S_8 for solutions of sulphur in different solvents.



It has therefore been assumed that three kinds of sulphur molecules may exist together in equilibrium as represented by the equations—

$$S_8 \rightleftarrows S_6 + S_2 \rightleftarrows 4S_2.$$

Determinations of the vapour density at different temperatures, carried out by the author in 1888, gave no indication of a steady vapour density in the neighbourhood of the temperature at which values corresponding to the formula S_7 were obtained, but on the contrary the values increased steadily with falling temperature up to 7·8 at 468° C. the lowest temperature at which measurements were made; the calculated values are 6·65 for S_6, 7·75 for S_7 and 8·86 for S_8. The results then obtained by working at constant pressure have now been confirmed by a series of measurements made at constant temperature; the whole series of measurements was made at the boiling-point of sulphur, and the pressure was varied from 14·0 mm. to 539·2 mm.; the values obtained are shown in the accompanying curve. The density is seen to increase continuously from a low value to one in excess of that required for the formula S_7, and appears to be converging asymptotically to the line representing the density for the formula S_8; no break occurs in the neighbourhood of S_6, and there is absolutely no experimental evidence for the existence of this kind of molecule. T. M. L.

364. *Influence of Molecular State of Solvent on Diminution of Vapour Pressure by Dissolved Salts.* **J. D. van der Waals.** (Archives Néerlandaises, 4. pp. 332–340, 1901.)—Let $1-x$ and x denote the fractional molecular concentrations of solvent and solute. The molecular weights meant here are the simple chemical molecular weights. Suppose the solute is a binary electrolyte. Owing to ionisation, x separates into $x-y$ unionised molecules, and $2y$ ions. Suppose the solvent is partially associated to double molecules; $1-x$ gives $1-x-2z$ single, and z double molecules. Let p denote the vapour pressure of the solvent. The following law is then deduced thermodynamically, $-\frac{dp}{pdx}=\frac{x}{x-\frac{y}{2}}+\frac{x}{1-x+2z}$. When x approaches an infinitely small value, the expression on the right hand becomes $1\Big/\left(1-\frac{y}{2x}\right)$. As in this case $\frac{y}{x}=1$, the limiting value is 2. Hence for the limiting case of infinite dilution the molecular state of the solvent does not influence the value of dp/pdx. F. G. D.

365. *Electrolytic Preparation of Sesquioxide and Salts of Chromium from Alkali Chromates.* **P. Straneo.** (Elettricità, Milan, 20. pp. 627–628, Oct. 5, 1901. From the *Rivista Tecnica.*)—The limited production of oxide of chromium at the kathode during the electrolysis of an alkali chromate has been known for some time, and in the laboratory of the Royal Industrial Museum it was found that a quantitative yield could be obtained if sufficient time were allowed for the operation; if the chromate be acidified, electrolysis gives, quantitatively, a *salt* of chromium. Recently Street has patented in England and Germany a process for electrolysing the chromate, in which he employs a kathode of mercury. The present paper gives a brief critical description of Street's process. D. H. J.

366. *Electrolysis of Ammonium Chloride Dissolved in Liquefied Ammonia.* **H. Moissan.** (Comptes Rendus, 133. pp. 713–714, Nov. 4, 1901.)—The author finds that such electrolysis at temperatures between —60° and — 80° furnishes only hydrogen at the negative pole and chlorine at the positive pole. [See also Abstracts Nos. 355 and 356 (1902).] D. H. J.

367. *Electrolytic Preparation of Monochlor-acetone and of Monobrom-acetone.* **A. Richard.** (Comptes Rendus, 133. pp. 878–880, Nov. 25, 1901.)—Monochlor-acetone is obtained by electrolysing a mixture of acetone and hydrochloric acid, and monobrom-acetone by a similar method. The yield increases with increasing voltage and with diminishing current density. D. H. J.

368. *Electrolytic Rectifier.* **E. Knoblauch.** (Phys. Zeitschr. 3. pp. 46–47, Nov. 1, 1901.)—The rectifier in question consists of a lead and an aluminium electrode standing in a 20 per cent. solution of sodium potassium tartrate (Rochelle salt). By means of it an alternating current may be employed with a Wehnelt interrupter for exciting induction coils in Röntgen-ray work. R. S. W.

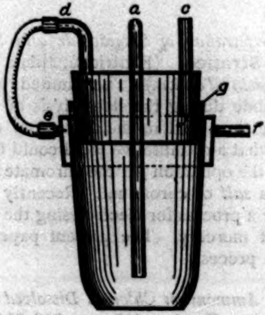
REFERENCE.

369. *The Significance of the Theory of Ions in Physiological Chemistry.* **T. Paul.** (Phys. Zeitschr. 3. pp. 28–31, Oct. 15, 1901. Paper read before the 73 Naturforscherversammlung at Hamburg.)

STEAM PLANT, GAS AND OIL ENGINES.

STEAM PLANT.

370. *Combustion Apparatus.* (Frank. Inst., Journ. 152. pp. 469–471, Dec., 1901.)—The Committee on Science and Arts of the Franklin Institute, issues a favourable report on the combustion apparatus invented by P. W. Shimer, of Easton, Pa., the object of which is to simplify the determination of carbon by the combustion method. Instead of the separate furnace with oxygen supply, and the usual tubes of platinum, porcelain, or glass, a platinum crucible is used, having the upper portion water-jacketed, with a water-cooled copper stopper provided with inlet and outlet tubes. A blast lamp and Bunsen burner supply the necessary heat, and air is employed for the combustion. The woodcut shows the apparatus, the crucible having the form and dimensions of ordinary crucibles used for fusions. The water-cooled chamber is on the outside ½ inch wide and ⅜ inch deep, with short inlet and outlet tubes *e* and *f* placed horizontally on opposite sides. The hollow stopper, made of sheet copper, has a copper tube *a* passing through it for admission of air to the crucible : *c* and *d* are copper tubes for inlet and outlet of the cooling water, *g* is a small rubber band to make a tight joint between the stopper and the crucible, and it is protected by the water-cooled surfaces. The arrows show the direction of flow of the water. The usual absorption tubes and filter tube for air are employed. F. J. R.



371. *Economy of Clearance in Small Steam Engines.* **A. Kingsbury.** (Horseless Age, 8. pp. 796–797, Dec. 11, 1901. Paper read at the New York meeting of the American Society of Mechanical Engineers (Dec., 1901). Slightly condensed.)—The author made an elaborate series of tests to determine the effect of clearance on the economy of a small steam engine (having cylinder of 5 inches diameter and 7 inches stroke), and found that there was a regular increase in the water consumption from 52 to 56 lbs. per i.h.p. per hour, as the clearance was increased from 10 per cent. to 34 per cent. The increase of clearance, however, was accompanied by an increase in exhaust pressure, corresponding to less complete expansion, also by decrease in compression; and these facts, together with the increase in clearance, were jointly responsible for the decrease in economy. E. H. C.-H.

372. *Automobile Boilers.* **J. W. Jones.** (Horseless Age, 8. pp. 817–819, Dec. 18, 1901.)—The suitability of various types of boilers for motor vehicles is considered, and also their relative economy. The author has compiled the following table from observations made during a recent 500-miles' road trial.

Type of Boiler.	Heating Surface in Square Feet.	Water Consumption (Speed, 15–18 Miles an Hour.	Water Consumption per Mile, in Gals.	Gasoline per Mile, in Gals.	Steam Pressure per Square Inch, in Lbs.
Victor fire tube......	50	26 gal. 20[1]	1·3	1–6	200
Tol. water tube ...	36	35 gal. 30[1]	1·16	1–6	200
White flash	30	20 gal. 26[1]	0·77	1–6	150 to 250

[1] Miles travelled.

The weight of all carriages with supplies and equipment was about 1,350 pounds.
Each boiler is rated at 6 h.p.

C. R. D'E.

373. *Stearns Compound Engine.* (Horseless Age, 8. pp. 748–749, Nov. 27, 1901.)—This is a neatly designed compound vertical engine suited to light steam motor cars. Both cylinders have piston valves, and centrally between these is a third piston valve, which serves as a steam distributor to the h.p. valve for either direction of rotation of the engine, and also enables high-pressure steam to enter both h.p. and l.p. valve chambers when extra power is required. The chamber in which the distributing valve moves forms the receiver for compound working. All the running parts are carefully gear-cased. A good sectional elevation is given. C. R. D'E.

GAS AND OIL ENGINES.

374. *Nash Gas Engine.* (Eng. News, 46. pp. 327–328, Oct. 31, 1901.)—The article decribes, with a section drawing, a Nash gas engine of 125 h.p. It is a vertical engine with three cylinders, 13½ inches diameter and 16 inches stroke, and running at 225 r.p.m. The ignition is electric. Starting is effected by supplying one cylinder from a compressed-air engine, the other two being supplied with gas. G. H. B.

375. *Point of Ignition in Gas Engines.* **C. E. Lucke.** (Horseless Age, 8. pp. 769–771, Dec. 4, 1901.)—An elaborate series of experiments was made with an Otto engine having a cylinder 5½ inches in diameter, with a 12-inch stroke. Sets of cards are reproduced, and the conclusion is arrived at that cards which have a vertical combustion line have not the greatest work area, but on the contrary, more work is turned out by the engine when the pressures do not rise so suddenly as to give a vertical combustion line. This is inexplicable except on the ground that at high pressures less heat is developed or more gets away suddenly, or that the specific heat of the gases rapidly increases with pressure. The author's results have been corroborated by a series of tests on a Fairbank Morse engine, reported in the Journal American Society of Mechanical Engineers, December, 1900. E. H. C.-H.

376. *Ignition.* **G. Lavergne.** (Locomotion Automobile, 8. pp. 753–754, Nov. 28, and pp. 769–770, Dec. 5, 1901.)—The Cannstat-Daimler firm are now using an alternating-current sparking apparatus having the advantages of the magneto while dispensing with any contact pieces subject to wear. Ignition by incandescence is based on the fact that spongy platinum or platinum wire will maintain incandescence when in contact with carburetted air. This system has no flame, and is not interfered with by wet or wind. Stoppage of the engine, or variation of the point of ignition, is easily determined by a valve controlling the admission of carburetted air on to the platinum. In this way a de Dion motor can be regulated over a range of 1,200 to 3,200 r.p.m. The objection to the method has chiefly been the danger of premature explosions, but this danger is absent in the Diesel motor, which only compresses pure air. E. H. C.-H.

377. *Dayton Dynamo for Electric Ignition.* **E. Dieudonné.** (Locomotion Automobile, 8. pp. 824–826, Dec. 26, 1901.)—This little machine is intended to replace the accumulators or dry cells usually fitted with the electric ignition apparatus of motor cars having internal combustion engines. It consists of a drum-wound armature, the spindle of which runs in bearings at either end of a barrel-shaped steel casing, which is permanently magnetised. The internal field poles are formed of soft iron, and the field coils are wound on them. The permanent magnetic field greatly facilitates the generation of sufficient current for starting the engine by hand. The armature spindle is driven by a friction cone controlled by a centrifugal governor, which causes the cone to slip above a certain speed. The machine weighs 10 kg., and developes 6 amperes 8 volts, at 1,400 r.p.m. C. R. D'E.

378. *Alcohol Motors.* **É. Hospitalier.** (Ind. Élect. 10. pp. 496–502, Nov. 10, 1901. Report of the trials instituted by the Minister of Agriculture.) —This paper contains full details of twenty-seven types of alcohol motors, together with the power and consumption figures on half and on full load. The tests were made with two grades of alcohol, viz., pure denaturalised alcohol, or "moto-schnick," consisting of 100 parts by volume of ethyl, 10 parts of methyl alcohol, and 0·5 part of heavy benzine, and "electrine" consisting of "moto-schnick" and light benzine in equal proportions. The b.h.p. trials were made with a Prony brake. The author points out the great advances which have been made in these motors during recent years, and that they now give practically the same power, for a given cylinder volume and piston speed, as petrol motors. C. R. D'E.

379. *Comparative Trials with Petrol and Alcohol.* **E. Dieudonné.** (Locomotion Automobile, 8. pp. 759–761, Nov. 28, 1901.)—This paper gives the results of experiments by H. Güldner on a single cylinder vertical engine, water-cooled and with electric ignition, cylinder 96 mm. bore × 100 mm. stroke, normal speed 1,000 r.p.m. The petrol used had a specific gravity of 0·68, and the alcohol was ordinary commercial alcohol of 88 to 90 per cent. purity. The horse-power was taken with a Prony brake. The average of the result gave 4·12 b.h.p. with petrol and 3·89 b.h.p. with alcohol. With petrol 351 gr. per b.h.p.-hour were consumed, and with alcohol 691 gr. per b.h.p.-hour. This is equivalent to 3,861 calories absorbed with petrol and 3,904 calories with alcohol per b.h.p.-hour, and a cost of 0 fr. 14 with petrol and 0 fr. 216 with alcohol per b.h.p.-hour, at present prices in Germany. A sectional elevation of the engine is given. C. R. D'E.

380. *Alcohol Motors.* **L. Perissé.** (Locomotion Automobile, 8. pp. 786–787, Dec. 12, 1901.)—This article gives the results of trials by Ringelmann at the trials organised by the Minister of Agriculture, France :—

(A) With alcohol carburetted with 50 per cent. of benzine. The consumptions per b.h.p.-hour were : Fritscher Houdry engine, 1·27 b.h.p. at 430 r.p.m., 645 gr. ; Aster engine, 2·3 b.h.p. at 1,600 r.p.m., 626 gr. ; Japy engine, 3·75 h.p. at 310 r.p.m., 409 gr. ; Otto engine, 6 b.h.p. at 240 r.p.m., 435 gr. ; Pruvost engine, 9·6 h.p. at 223 r.p.m., 379 gr. ; Merlin engine, 3 h.p. at 280 r.p.m., 529 gr. ; Bruhot engine, 16·1 h.p. at 176 r.p.m., 382 gr. Attention is directed to the comparison of these results with some obtained with an "Economique" engine tested in Switzerland. This engine gave 20·1 b.h.p. at 200 r.p.m., and consumed 272 gr. of 50 per cent. alcohol, 324 gr. of 80 per cent. alcohol (20 per cent. benzine), and 356 gr. of pure commercial alcohol per b.h.p.-hour.

(B) With pure commercial alcohol the consumptions per b.h.p.-hour were as follows : Japy engine, 3·75 b.h.p. at 308 r.p.m., 565 gr. ; Pruvost engine, 9·6 h.p. at 222 r.p.m., 507 gr. ; Duplex engine, 8·2 h.p. at 230 r.p.m., 710 gr. ; Gnome engine, 4 h.p. at 368 r.p.m., 674 gr. ; Phoénix engine, 6·22 h.p. at 490 r.p.m., 688 gr. ; Bardon engine, 2·6 h.p. at 800 r.p.m., 862 gr. ; Bruhot engine, 16 b.h.p., 491 gr. ; "Economique" engine, 3·04 b.h.p. at 253 r.p.m., 475 gr. Engines by the same maker of 15 b.h.p. and 30 b.h.p. consumed respectively 356 gr. and 387 gr.

The author considers that the proportion of methylene added to alcohol in France should be reduced from 10 per cent. to 1 per cent. C. R. D'E.

381. *Centaure Motor.* **F. Mirès.** (Locomotion Automobile, 9. pp. 7–8, Jan. 2, 1902.)—This is a new type of petrol engine, built by the firm of Panhard and Levassor, Paris. It has four vertical cylinders cast in pairs, and bolted to an aluminium crank chamber. The cylinder bodies and heads are cast in one piece, and the induction valves are mounted vertically over the exhaust valves. The cylinders are water-cooled, and both tube and electric ignition are fitted. The cam gear for the exhaust valves is enclosed within the crank chamber, but the 2 to 1 gear and the governor are external, as in other engines by the same firm. The governor acts by restricting the admission to all cylinders equally. The engine developes 35 b.h.p. at 750 r.p.m., and weighs about 350 kilogrammes. C. R. D'E.

AUTOMOBILISM.[1]

382. *Motor Car Design.* **M. H. Smith.** (Inst. Mech. Engin., Proc. 3. pp. 699–717, 1901.)—The paper contains a description of the author's latest pattern of petrol car. The most interesting point is the use of belt-driving with cones for speed-change. A special form of link-belt was evolved, and is found very satisfactory. E. H. C.-H.

383. *Tractive Force Required in Automobiles.* **H. E. Wimperis.** (Écl. Électr. 29. pp. 330–334, Nov. 30, 1901.)—The author proposes to deal with the question by observing the time which a vehicle takes to slow down when left to itself. After the vehicle has reached full speed on a level road, he notes the rate at which the velocity decreases when the motive power is withdrawn. He then constructs a curve connecting the speed with the time, the latter being reckoned from the moment when the car is left to itself; and thence he deduces a second curve connecting the speed with the distance travelled. The retarding force may be deduced by observing the time t which elapses during any small reduction of speed, say from 21 km. to 19 km. an hour. If M is the mass of the vehicle, the retarding force is given by the equation—

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[1] Electric Automobiles are described in the Section dealing with Electric Traction.

$$F = M\frac{\text{variation of speed.}}{t}$$

If t is made sufficiently small, approximations can be found to the value of F, and a curve can then be drawn connecting F with the velocity. In order to determine F with greater accuracy, recourse must be now had to analytical methods. The tractive resistance contains three terms; the first is a term due to axle and rolling friction (Ewing has shown that rolling friction is independent of the speed, and depends solely on the pressure, and on the nature of the tyres and road surface); secondly, a term proportional to the speed, due to the roughness of the road; thirdly, a term due to air resistance. The first two terms are proportional to the mass of the vehicle, but the third depends on the vertical surface exposed rather than on the mass. Nevertheless, we may assume that—

$$F = Mg(a + bv + cv^2),$$

where a, b, c are constants, and g is the acceleration due to gravity. The equation to be solved is therefore—

$$M\frac{dv}{dt} + Mg(a + bv + cv^2) = 0,$$

whence we get—

$$t = \frac{2}{fg}\tan^{-1}\frac{2cf(V - v)}{f^2 + (2cV + b)(2cv + b)},$$

where $f^2 = 4ac - b^2$, and V is the initial velocity. Similarly it is possible, on the above assumption, to obtain a relation between the distance travelled (d) and the velocity. Assuming certain values for a, b, and c, as deduced from the curve connecting F and v mentioned above, it will then be possible to see how far the theoretical values of t and d agree with the curves practically obtained. By the introduction of successive approximations, the values of a, b, and c can be obtained with considerable accuracy, in such a way as to make the theoretical calculations agree with the curves. The author contends that this method can be applied with great ease, the only laborious part of the work being that which involves the evaluation of a, b, and c. Thus in the case of a bicycle he has found that—

$$F = \frac{P}{132}\left(1 + \frac{v}{20} + \frac{v^2}{84}\right),$$

where F and P (weight) are calculated in pounds, and v in miles per hour.

W. H. S.

384. *René Legros Light Car.* (Locomotion Automobile, 8. pp. 774–776, Dec. 5, 1901.)—In the vehicle illustrated, a light channel steel underframe carries towards its front end a double cylinder vertical engine adapted to use either petrol or alcohol. The engine may, however, have one or more cylinders according to the power required. The power is transmitted through a cone clutch and a special form of spring drive to one shaft of the change speed gear. The changes of gear are effected by means of spur wheels which are always in gear, any one set being made drivers by means of

an arrangement of claw clutches. From the second motion gear shaft the power is transmitted through a jointed steel shaft to a bevel pinion which gears with a bevel wheel ring mounted on the exterior of the differential on the live rear axle. C. R. D'E.

385. *Delahaye Light Car.* (Locomotion Automobile, 8. pp. 790–791, Dec. 12, 1901.)—In this car a rectangular tubular underframe carries at its front end a horizontal single-cylinder engine, the crank-shaft of which is extended to one side, and carries a flywheel and a broad belt pulley. The engine is water-cooled, a pump and radiator being fitted. The carburettor is adapted for using either petrol or alcohol, and electric ignition is fitted. The power is transmitted by belt to a sleeve forming part of the differential gear-box, which is mounted upon a cross-shaft placed transversely to the length of the frame and parallel to the engine shaft. On the sleeve is a central loose pulley, and driving pulleys at either side of this give motion to the shaft for either forward or reverse motion of the car. When the belt is on the driving pulley which is outside the loose pulley the power is transmitted direct to the differential cross-shaft, while with the belt on the inner driving pulley, motion is first transmitted to a counter-shaft by spur gears giving the intermediate, lowest, or reverse speed, and then the motion is imparted to the differential sleeve and shaft through a spur drive. The power is finally transmitted to the road wheels by independent chain drives. Plan and elevation drawings of the mechanism and a photograph of the car are given. C. R. D'E.

386. *Panhard and Levassor Light Car.* **F. Mirès.** (Locomotion Automobile, 8. pp. 821–823, Dec. 26, 1901.)—In this vehicle the main underframe is of wood, and to it is attached a subsidiary metal frame supporting the engine and change gear. The engine is of the double cylinder vertical type, with pistons coupled to cranks at 180°. The cylinder dimensions are 80 mm. or 90 mm. bore and 120 mm. or 130 mm. stroke, for 5 or 7 b.h.p. at 750 r.p.m. The cylinders are water-cooled, and both tube and electric ignition are fitted. The engine is mounted towards the front of the frame, and the power is transmitted through a cone clutch to the change gear, which gives three speeds forward and one reverse, by means of spur wheels engaged by side contact, and is finally delivered to the road wheels from the differential cross-shaft by independent and chain drives. The differential cross shaft is carried in spherical bearings fixed at the junction of the metal and wood frames, and is thus relieved of strains resulting from deformation of the frames.
C. R. D'E.

387. *Holden's Motor Bicycle.* (Automotor Journal, 6. pp. 95–100, Dec. 16, 1901.)—This bicycle has a tubular frame resembling a Warren girder in construction, the engine itself forming the bottom stay. In the spaces between the frame members are arranged the carburettor and petrol tank, the water tank, and the induction coil and battery. The engine has two horizontal cylinders, each with two pistons so arranged that either end of each cylinder body forms a combustion chamber, while the central portion of the cylinder wall in each case supports the guide of the single cross-head pin to which all four pistons are coupled. The guide-pin is free to turn in its guides, and has fixed to its ends long connecting rods which couple it to crank arms at the ends of the rear wheel axle. The rear wheel is of small diameter so as to admit a fair speed of rotation of the engine. The four combustion chambers of the engine are water-cooled, and have automatic admission and mechanically

operated exhaust valves. Electric ignition is employed, the four sparking plugs being fed from a single induction coil by means of a special high-tension distributor. A mechanical lubricator distributes oil to the cylinders. Several good illustrations are given. C. R. D'E.

388. *Brouhot Underframe and Gear.* (Locomotion Automobile, 8. pp. 793–794, Dec. 12, 1901.)—This mechanism consists of a rectangular tubular underframe carried by single plate springs from front and rear axles. The engine is of the double cylinder horizontal type, and is mounted with its longitudinal centre line on that of the underframe, and with crank-shaft practically at the centre of the length of the frame. The gear-box is mounted close up behind the crank chamber of the engine. At one end of the crank-shaft is mounted the flywheel and cone clutch, and on the clutch sleeve is a spur-wheel gearing, with a similar wheel on the first motion shaft of the change gear. By means of spur wheels and pinions three forward speeds and one reverse are obtained. The power is transmitted from the change gear to the live rear axle by a chain drive. There is no differential gear on the live axle, but the wheels are enabled to turn at different speeds by a special ratchet and paul drive. Plan and elevation of the mechanism are given, and a detail of the ratchet drive. C. R. D'E.

389. *Variable Speed Gear.* **G. Jougla.** (Locomotion Automobile, 9. pp. 8–10, Jan. 2, 1902.)—This gear, which is the invention of R. de Montais, is of the expanding belt pulley type. On each pulley shaft are two sliding bosses, with a fixed boss between them. To the sliding bosses are pivoted the inner ends of levers whose outer extremities are pivoted to the plates which form the pulley rim, and which are interlaced by a system of levers. On the fixed central boss are pivoted short arms which are also pivoted to the main pulley arms at the centre of their length. Spiral springs are mounted on the pulley shafts so that they press upon the sliding bosses and tend always to expand the pulleys by forcing together the sliding bosses. By means of a system of levers the sliding bosses of one of the pulleys are under control, and the diameter of this pulley can be varied at will. As one pulley expands, the other contracts, due to the increased belt tension. The belt may be caused to run loose by fixing the diameter of the pulley ordinarily under control and pulling out one loose boss of the other pulley, and so reducing its diameter. C. R. D'E.

390. *Suspension for Gasoline Motors.* **H. D. Meier.** (Horseless Age, 8. pp. 652–653, Nov. 6, 1901.)—The author criticises the usual methods of rigidly attaching the engines of motor cars to metal underframes, or in some cases direct to the rear axle itself. Certain methods of spring suspension are discussed, and two methods of applying rubber buffers between the supporting arms of a petrol engine and a channel or angle steel frame are illustrated. C. R. D'E.

REFERENCE.

391. *Air Navigation.* **H. Deslandres.** (Comptes Rendus, 133. pp. 993–996, Dec. 9, 1901.)—A method is given of determining the speed of a dirigible ærostat, with application to the experiments of Santos-Dumont. [See Abstract No. 2457 (1901).] E. H. C.-H.

GENERAL ELECTRICAL ENGINEERING.

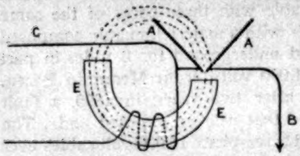
392. 10,000-*Volt Cable in* 1888. **O. Schaefer.** (Electrician, 48. pp. 178–180, Nov. 22, 1901.)—A cable with three strands, each of nineteen strands of 1·53 mm. in diameter, insulated with vulcanised rubber to a radial thickness of 4·25 mm. on each core, and also a cable with three cores of the same copper, insulated to the same radial depth with a material, mainly composed of hydrocarbons, called Kabelit, were laid underground for 3 miles in part of a 25-mile overhead transmission at 11,000 volts, from Meran to Bozen. They were tested to 20,000 volts, and after two years, in 1890, a fault developed in the rubber cables alone, and that near an exposed end. The author claims these to be the first stranded three-phase 10,000-volt cables ever made. The capacity per mile reaches the high figure of 0·78 microfarad per mile for rubber and 0·568 microfarad for Kabelit. M. O'G.

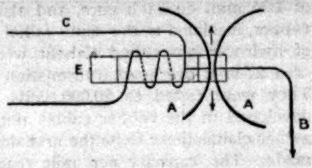
393. *Influence of Temperature upon the Output of Lead Accumulators.* **C. Liagre.** (Écl. Électr. 29. pp. 149–152, Nov. 2, 1901.)—After referring to previous results obtained by Gladsone and Tribe, and by C. Heim [see Abstracts Nos. 220 and 2465 (1901)], and also to the various formulæ for calculating the output of a cell, taking into account its rate of discharge, the author describes experiments made by himself upon a cell having electrodes, both positive and negative, of the Planté formed type. A number of different discharge rates from 25 to 180 amperes were selected, and at each rate a series of discharges was taken at temperatures ranging between 15° and 70° C. For each set of discharges the curve of increase of output with temperature proves to be a straight line, and all the lines have the same inclination to the axes, that is, they are parallel and indicate the same rate of increase in each case. The average coefficient of increase was 2·7 ampere-hours per deg. C., and it never varied through wider limits than 2·55 to 2·8 ampere-hours per deg. C. The lower the discharge rate, the bigger the output for any given temperature—this is also illustrated by curves—and it follows that the *percentage* increase of output with temperature goes up with the rate of discharge. The whole gist of the paper is to emphasise the relationship between these two variables. E. J. W.

394. *Magnetic Dynamometers.* **J. Guillaume.** (Écl. Électr. 29. pp. 189–196, Nov. 9; and pp. 265–276, Nov. 23, 1901.)—The method of ascertaining the h.p. of a motor by absorbing the power by means of a rotating disc of copper or iron cutting a magnetic field is discussed, and four types are described: (1) Siemens and Halske, (2) Pasqualini, (3) Feussner, and (4) Rieter. Photographs and drawings show the details and method of use in each case. The Rieter brake differs from the others in having the inductor part in construction like an alternator. In April, 1900, Rieter was presented with a medal by the Société Industrielle de Mulhouse for his invention, which was required to measure 20-h.p. to the one-fiftieth part at least. Experiments made by H. F. Weber with the brake are described. It is shown how the apparatus of Pasqualini may be used as an hysteresimeter. Finally a practical example of the use of the last-mentioned brake for testing at the electrotechnical laboratory of the Italian navy at Spezzia is cited. W. W. H. G.

395. *Safety Devices for Protecting Overhead Lines against Dangerous Pressures.* **G. Benischke.** (Elekt. Runds. 19. pp. 39–41, Nov. 15; and pp. 50–52, Dec. 1, 1901.)—The lightning protector here described is designed to protect the lines also against rise of potential due to silent discharge, and has bow-shaped horns A, arranged as shown, in side elevation and plan, in the accompanying diagrams.

One of these horns is connected to earth through the conductor B, whilst the other is connected to the line C to be protected. This line is wound once or oftener round a laminated iron core E, one of the poles of which lies below the sparking point, or place where the horns lie nearest together.





In another device, for protecting alternate-current mains from the effects of excessive pressure due to resonance, each of the lines is connected to one pole of a pair of adjustable sparking pieces, the other poles of which are connected together, and to earth, through non-inductive resistances—*e.g.*, water-resistances. C. K. F.

REFERENCE.

396. *Electric Crane.* (Zeitschr. Vereines Deutsch. Ing. 45. pp. 1559–1561, Nov. 2, 1901.)—The article describes the construction of a crane, lifting 100 tons, erected on a wharf at Bremen. Several drawings are given, showing the general arrangements. W. H. S.

GENERATORS, MOTORS, AND TRANSFORMERS.

397. *Large Alternators.* **A. Rothert.** (Écl. Électr. 29. pp. 307–328, Nov. 30, and pp. 362–374, Dec. 7, 1901.)—The author gives a table containing full constructional details of twenty-three different types of large alternators, most of which were exhibited at Paris in 1900, and then briefly comments on the characteristic features of the various machines. The peripheral velocity varies from 14 to 38·5 metres per second. Of the twenty-three machines referred to, six had hole windings, eleven slot windings with the slots nearly but not quite closed at the top, and the remainder had entirely open slots. The number of slots per pole in the case of three-phasers varies from three to fifteen, the number most commonly employed being six; with only three slots per pole there is a very prominent third harmonic in the e.m.f. wave. The armature coils in almost every case have a width equal to the pole pitch. The air-gap varies from 6 to 8 mm. The pole-pieces are in some cases solid, in others laminated; in the author's opinion, they may be solid if, with at least six slots per pole (in the case of three-phasers), the width of the slot at the top does not exceed half the length of air-gap. The length of the pole-piece parallel to the armature circumference is in most cases two-thirds of the pitch. The current-density in the field coils mostly exceeds 3 amperes per sq. mm. (about 2,000 amperes per square inch), and in the armature coils falls below this value. The induction in the armature core-discs is in most cases 4,000 to 5,000 (for 50-cycle machines). The leakage coefficient of the field magnet varies from 1·18 to as high a value as 1·74; the author draws attention to the importance of calculating this coefficient. The ratio of armature to field ampere-turns seldom exceeds 0·3 (it varies between 0·15 and 0·47). The copper loss in the armature varies from 0·7 to 2·5 per cent., and the iron loss from 2·25 to 5·5 per cent., in most cases exceeding 4 per cent. The copper loss in the field varies from 0·36 to 2·6 per cent. The dimensions of different machines of the same output, and running at the same speed, vary considerably, and the author considers that there is plenty of scope for reducing the dimensions below their present-day values. A. H.

398. *Alternators with Dampers.* **J. Fischer-Hinnen.** (Elect. World and Engineer, 38. pp. 1058–1062, Dec. 28, 1901.)—The form of damper (amortisseur), originally described by Leblanc, consisted of a kind of copper ring on each magnetic pole of the alternator. Its effect was to reduce the drop of pressure by choking back part of the armature reaction. It was no real help for the parallel running of single-phase machines, as outside energy was required for synchronising the rotor. For polyphase machines, however, it was useful, as when they were running in synchronism no effect was produced on the damper, which acts only when the rotor gets out of synchronism. The author considers that the action of the damper is identical with that of the secondary winding of an asynchronous motor. He first of all developes the theory of polyphase motors, and then applies his formula to show the action of the dampers in polyphase generators. He investigates the problem of the influence of the damper on the working of a flywheel machine which has a variable speed on account of the unfavourable position of the crank. Under these circumstances he shows that the damper has some slight influence on the uniform running of the machine. Its main use is to insure greater stability for paralleling. He considers that in many cases single-cylinder engines are preferable to compound engines. He points out that the change from maximum to minimum speed is steadier for a single-cylinder engine than for a compound engine, although, of course, the energy variations during each stroke are greater for the single-cylinder engine. The compound engine is much more likely to produce high harmonics in the e.m.f. wave. If a machine is run only for an hour or two at full load, and on a light load for the remainder of the day, then a good single-cylinder machine is the more economical in steam consumption. Some large generators, quite capable of supplying the night load, are yet not able to furnish the magnetising current for the transformers in the daytime, owing to the great pressure drop. For single-phase generators dampers are of very little use. They only reduce the pressure drop by about 30 per cent. Figures from actual machines are quoted to show that the weight of copper in the damper is about half that on the field. He says that the same purpose could have been attained at one-fifth the cost by strengthening the magnetic field. A. R.

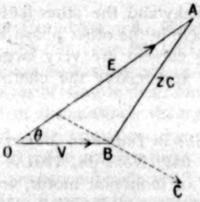
399. *Parallel Running of Alternators.* **E. J. Berg.** (Amer. Inst. Elect. Engin., Trans. 18. pp. 781–785, Oct., 1901.)—A mathematical investigation is made of the principles governing the parallel running of alternators when driven by steam engines or turbines. It is proved that if we neglect the resistance of the armatures as compared with their inductance, then the alternators divide the load inversely as their reactances. Hence, if we have two machines running in phase, each of which generates the same e.m.f., then, if the armature reaction of one is double that of the other, it will only take one-third of the total load. To balance the load we must therefore—(1) add reactance to one armature, (2) rigidly connect the armatures together so that the e.m.f.'s are slightly out of phase, or (3) run them at excitations which will cause considerable cross currents. There is a definite tendency to "hunt," and this flow of power from one to the other is much greater than can be made up by the stored energy of the armature flywheels. It must, therefore, be supplied by the steam. Hence the flow of steam must be periodic to keep up the "hunting." The best remedy is to prevent this periodic flow of steam by proper dashpot arrangements at the governor. To use short-circuited windings in and around the field of the alternators is objectionable, owing to the losses due to the induced currents caused by the pulsations of flux incidental to the construction of modern ironclad armatures. A. R.

400. *Variations in the Exciting Current of an Inductor Alternator.* **W. Duddell** and **E. W. Marchant.** (Electrician, 48. pp. 224–225, Nov. 29, and pp. 302–304, Dec. 13, 1901.)—Measurements were made of the wave form of the exciting current of an inductor alternator by the Joubert contact method, and the authors give clear theoretical explanations of the results of their experiments. They prove (1) that the variations of the exciting current may be considerable in certain cases. (2) The exciting current is made up of a direct and an alternating current component, the frequency of the latter being double that of the armature e.m.f. (3) The added alternating current is asymmetrical. (4) The amplitude of this current depends very little on the resistance of the field circuit. (5) The maximum values of the exciting current on open circuit occur approximately when the armature e.m.f. has its maximum or minimum values. (6) In this case also the amplitude of the

exciting current is nearly proportional to the amplitude of the armature e.m.f. wave, the speed being kept constant, and (7) it is practically independent of the speed for constant mean exciting current. (8) The superimposed alternating current in the field is reduced when the machine is loaded, and becomes very small when the machine is short-circuited. (9) These variations in the exciting circuit tend to reduce the efficiency of the machine owing to hysteresis and eddy current losses. (10) The e.m.f. in the field coil may prove dangerous to insulation, &c., owing to resonance effects. The authors point out how this effect can be completely eliminated by properly designing the machine. A. R.

401. *Period of Natural Oscillation of Alternator Coupled to Bus-Bars.* **M. Soubrier.** (Écl. Électr. 29. pp. 177–178, Nov. 2, 1901.)—The approximate formula for the period of the oscillations of the rotor of an alternator connected to the bus-bars has been given by Blondel and Boucherot. [See Abstracts Nos. 340 and 341 (1900).]

A simple proof of the formula can be given as follows: In the figure let OA be the vector e.m.f. of the alternator and OB(V) the p.d. between the bus-bars, then BA will equal ZC where Z is the impedance of the armature and C is the current. Suppose that the resistance of the armature is negligible compared to its inductance so that BC the current vector is perpendicular to AB, then if P be the power given to the network by the alternator,



$$P = EC \cos \hat{EC} = \frac{AO \cdot AB \sin \hat{A}}{Z} = OB \cdot \frac{OA}{Z} \sin \theta = VI \sin \theta.$$

Hence if θ be small the retardation of the rotor is proportional to θ; the motion is therefore simple harmonic, and—

$$T = 2\pi n \sqrt{\frac{2\pi MK^2}{fVI}},$$

where $T =$ the period of the oscillation in seconds, $n =$ the number of revolutions per second, $M =$ the mass of the rotor in kilogrammes, $K =$ its radius of gyration in metres, $f =$ the frequency, $V =$ the bus-bar voltage, $I =$ the short-circuit current of the alternator. A. R.

402. *Study of Polyphase Machines by the Oscillograph.* **A. Blondel.** (Écl. Électr. 29. pp. 391–400, Dec. 14, 1901.)—Complete data are given of experiments on a two-phase and a three-phase machine, which were driven by a direct-current motor connected to a battery of accumulators so as to insure constant speed. The characteristic curves are given of the machines on open circuit, on inductive and non-inductive loads, and on short circuit. Experi-

ments were also made to find out how the voltages in the various phases altered when one was loaded and the others left on open circuit. The results agree very closely with those arrived at by the ordinary theory. When, however, the instantaneous values of the exciting current, the volts and the armature currents, were oscillographed, very curious effects were observed. On open circuit the three-phaser gave a very approximate sine curve, and the exciting current was practically a straight line. When one phase was loaded the exciting current pulsated with a frequency twice that of the alternating current (see Blondel, *La Lumière Électrique*, Sept. 12, 1891). When the three phases were loaded symmetrically the frequency was six times that of the armature current, but the amplitude of the disturbance was much smaller. Similarly in the two-phase machine the frequency of the pulsation of the exciting current was four times that of the armature current.

A non-inductive load on one of the phases lowers the e.m.f.'s in the others. If the load be a capacity load, then the other e.m.f.'s may be slightly raised. The shapes of the p.d. waves on unequal loads are of course quite different. In the three-phaser the shape of the p.d. wave across the loaded phase is approximately sinoidal, that across another is a peaky wave, and across the third a flattened wave. In the two-phaser the effects of the armature slots on the shape of the p.d. wave are very pronounced, making it rippled. When one phase is loaded enormous distortions from the sine shape are produced. One p.d. wave becomes peaky and the other flattened. When one phase is short-circuited the p.d. wave in the other phase loses its symmetry, and the pulsations of the exciting current are very large. It is curious that these effects do not alter very appreciably the characteristics of the machines.

A. R.

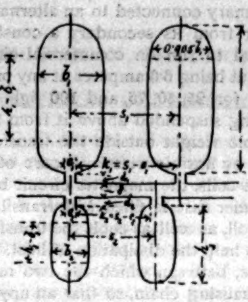
403. *Measurement of Slip in Induction Motors.* **A. Schweitzer.** (Elektrotechn. Zeitschr. 22. p. 947, Nov. 14, 1901.)—The stroboscopic method of measuring the slip in an induction motor, first described by Benischke, is frequently employed, a simple white mark on the rotor being viewed by the light coming from an arc lamp fed from the circuit supplying the motor. The number of apparent revolutions of the white mark during a given time enables us to find the slip. The objection to the use of an arc lamp is the comparatively large current which it takes. The author has tried the use of incandescent lamps for this purpose [following a suggestion of Samojloff's, see Abstract No. 117 (1901)], but finds them unsatisfactory. A Braun tube may, however, be used with advantage. The induction coil supplying the tube is worked by an interrupter driven by the rotor of the motor under test, and the rotating field which produces the deflection of the kathode rays is due to suitably arranged coils connected to the generator. From the number of apparent revolutions of the luminescent spot on the screen of the tube, corresponding to a given number of rotor revolutions, the slip is at once obtained.

A. H.

404. *Calculation of Three-phase Induction Motors.* **O. Weisshaar.** (Elektrotechn. Zeitschr. 22. pp. 943–947, Nov. 14, 1901.)—After a brief discussion of the induction motor diagram, the author gives the following formula for the leakage factor τ_1 of the stator (*i.e.*, ratio of stator leakage flux to main flux)—

$$\tau_1 = \frac{4\delta}{\frac{3}{2}(q_1 k_1 + q_2 k_2)} \left(\frac{h_1 - b_1}{q_1 b_1} + \frac{1}{0{\cdot}905 q_1} + \frac{e_1}{d_1} + \frac{2\delta}{\frac{3}{2}(q_1 s_1 + q_2 s_2)} \right),$$

where the meanings of most of the symbols are evident from the accompanying sketch, and q_1, q_2 denote the number of stator and rotor slots respectively per pole and per phase. The rotor leakage coefficient τ_2 (ratio of rotor leakage flux to main flux) is obtained by interchanging the suffixes 1 and 2 in



the above formula. Two numerical examples are worked out, and the calculated results agree very well with those obtained experimentally. [See further Abstract No. 1939 (1900).] A. H.

405. *Regulation of Rotary Converters.* **A. Blondel.** (Écl. Électr. 29. pp. 206–217, Nov. 9; and pp. 283–293, Nov. 23, 1901. Paper read before the Congrès Intern. des Électriciens.)—The theory of the regulation of rotary converters is discussed by means of simple diagrams. The method of treatment is similar to that used in the author's theory of synchronous motors [see Abstract No. 2010 (1901)]. He considers the magnetic field as due to three magnetomotive forces: (1) The ampere turns of the exciting current; (2) the ampere turns in the armature which are "wattless" with regard to the applied p.d.; and (3) the difference between the "watt" ampere turns and the secondary ampere turns produced by the direct current. (1) and (2) act in the same direction. (3) is always extremely small and can be neglected in practice. Hence, in theory, a converter can be considered as a simple case of a synchronous motor, namely, the case when the cross magnetisation of the armature can be neglected. The author's "principle of two reactions" is thus directly applicable. He uses very similar diagrams to those he employs for alternators and motors, the e.m.f.'s and the currents being represented on the same diagram by different scales and from different polar axes. He gives a formula for the most advantageous reactance of the converter when supplied at constant p.d. The most perfect theoretical way of regulating the converter would be to alter the applied p.d. in such a way that the converter would have practically unit power factor at all loads. This could be done by a suitable alternator. If the applied p.d. is constant, then suitable choking coils have to be put in series with the converter. In the second part of the paper the best ways of exciting the converter in various cases are determined. When the regulation is effected by choking coils and the applied p.d. is constant, then a simple shunt winding is suitable. If the applied p.d. increases with the load, then a compound winding is best, the shunt windings required being determined by the voltage of the unloaded machine, and the series windings by the voltage at full load. The diagrams given by the author can be combined with experimental data so as to give exact numerical results. A. R.

406. *Constant Current Transformer for Alternating Series Arc Lighting.* (Frank. Inst., Journ. 152. pp. 855–869, Nov., 1901. Report of the Franklin Institute on the invention of Prof. Elihu Thomson.)—This transformer is intended to have its primary connected to an alternating circuit of constant potential, and to deliver from its secondary a constant current of varying potential. It is designed to run on commercial circuits of 1,100 or 2,200 volts, the secondary output being 6·6 amperes at any pressure up to 6,000 volts.

The sizes made are for 25, 50, 75, and 100 lights. The primary coil is fixed, the secondary being suspended above it from the end of a lever, and balanced by an adjustable weight outside the transformer. Connections to the secondary are made by flexible wires. A core of iron stampings passes through the centre of the coils, the magnetic circuit being completed outside the coils. The transformer case is filled with transil oil, which steadies the motion of the movable coil, as well as cools the transformer. The outside of the case is corrugated to help the dissipation of heat. Larger sizes are made with two fixed primaries, between which the two movable secondaries are placed, joined by an equalising chain, so that an upward motion of the one corresponds with an equal downward motion of the other. The lever which carries the counterweight has a sector at the end of it which can be tilted at various angles; altering the weight changes the average current, while tilting the sector varies the strength of the current through the range of the machine. With a change in the external circuit, the secondary, under the influence of the repulsion of the primary, and the lifting action of the lever, assumes a new position of equilibrium, in which fewer or more lines of force due to the primary are cut by the secondary, according as the latter has approached or receded from the primary. The effect is that the secondary voltage is increased or diminished as the case may be, and the secondary current remains practically constant. The primary current also remains nearly constant, but with an increased angle of lag at lighter loads. Curves and tables are given showing the result of a test made on a 50-light transformer with 2,200 volts on the primary at 60 periods. When the number of lamps on the secondary was varied from 50 to 15 by steps, and back again, the current only varied between 6·52 and 6·7 amperes; the volts per lamp, however, increased as the load was diminished from about 77 to 86. This is explained as being due to the alteration in the current wave form, the curve becoming less peaked. On account of this action the makers adjust the transformer so as to give approximately constant watts per lamp. B. P. S.

REFERENCE.

407. *Breakdowns of Electrical Machinery.* **M. Longridge.** (Mech. Eng. 8. pp. 456–458, Oct. 5, 1901.)—This paper is a reprint of a portion of the author's annual report as chief engineer of the Engine, Boiler, and Employers' Liability Insurance Company, and contains a summary of the more important breakdowns in connection with dynamos and motors that have come under the notice of the company during the past year.

ELECTRICAL DISTRIBUTION, TRACTION AND LIGHTING.

ELECTRICAL DISTRIBUTION.

408. *Cost of Power.* **C. D. Gray.** (Frank. Inst., Journ. 152. pp. 275–298, Oct.; 331–350, Nov.; and pp. 421–439, Dec., 1901.)—The paper is a valuable collection of data on costs and efficiencies of different power engines. *Man Power.*—Average value for steady work $\frac{1}{10}$ h.p. *Animal Power.*—Average values for steady work in drawing load: Horse, 0·785 h.p.; ox, 0·66 h.p.; mule, 0·50 h.p.; ass, 0·25 h.p. Cost of one h.p. year, including interest, depreciation, and driver, £89. *Water Power.*—Tables are given of efficiency tests. Tangential wheels have efficiencies of from 85 to 90 per cent. in large sizes and from 75 to 85 in small sizes at full load. Turbines have efficiencies of from 80 to 85 per cent. above three-quarter load. The capital cost of water-power plants is £8 to £12 per b.h.p. excluding dam, and £12 to £20 including dam. Costs per h.p. year are given for 12 plants, and vary from 25 to 90 shillings; the average is 43 shillings. *Steam Power.*—A large number of tests of American coal show a calorific value of 14,450 B.Th.U. for anthracite and 14,470 for bituminous coal per lb. Heavy Pennsylvania petroleum gives on the average 20,000 B.Th.U. per lb.; light, 18,000, and Ohio and West Virginia oils give 18,500 per lb. Results of 192 boiler tests are given, showing an average evaporative power for all kinds of coal of 10·8 lbs. of water per lb. of coal for water-tube boilers, and 10·4 for tubular boilers, the steam temperature being 212° F. Figures of 250 engine tests are quoted; the averages, expressed in lbs. of steam per i.h.p., are:—

	Slide Valve.	Corliss.
Simple, non-condensing	33·8	29·0
Compound „	26·2	24·0
Simple condensing	23·1	22·6
Compound „	20·6	17·7
Triple „	17·0	14·2

Large pumping engines, simple	19·9
„ „ compound	15·3
„ „ triple	12·3

A table is given of steam-power costs per h.p.-hour; the standing costs vary from 0·045d. to 0·37d., the operating costs from 0·115d. to 1·22d., and the total costs from 0·155d. to 1·45d. The average total cost is 0·475d. For large compound condensing engines the average is 0·353d. *Gas Engines.*—Tables of calorific values of different gases give the following average values expressed in B.Th.U. per cub. feet.:—

Natural gas	1,033
Coal gas	706
Water gas carburetted	651
„ uncarburetted	319
Producer gas	143
Blast-furnace gas	102

Tests of gas engines give the following averages :—

Natural gas	9·85 cub. ft. per b.h.p.
Coal gas, small engines	22·9 „ „
Producer gas	82·0 „ „
„	62·9 „ per i.h.p.
„	1·04 lbs. coal per i.h.p.
Blast-furnace gas	115 cub. ft. per b.h.p.

Tables of costs are given of power from gas engines and of electric power for lighting and for traction ; also of efficiencies of electrical machinery, of different illuminants, and of power transmission systems. G. H. B.

409. *Power Distribution.* **C. F. Scott.** (Amer. Inst. Elect. Engin., Trans. 18. pp. 821–826, Nov., 1901.)—The question here discussed relates to the distribution of energy from alternate current generators, and the author enquires whether it is desirable to convert to direct current by means of rotary converters, and if so, under what circumstances. His views may be summarised as follows. Incandescent lighting can be carried out equally well either by alternate or direct current ; arc lighting, now most extensively carried out by enclosed arc lamps, can be provided either by direct current or by 60-cycle alternate current ; the Nernst lamp works well on alternate current but not on direct current ; for motor work there is little to choose, except in those cases in which a variable speed is required, while for constant speed work "probably no one will question the superiority of the induction motor from the standpoint of the man who uses the motor and pays for the repairs," and objections as to power factor, starting current, and voltage regulation can be met by a proper design of the system. On the whole from these points of view there appears to be little to choose. But when the matter is considered from the point of view of cost, simplicity, &c., the direct current appears at a disadvantage. The great difference arises in the matter of sub-stations. For power distributed by alternate current the substations contain merely static transformers, which can be placed in any convenient position, and their number is comparatively unimportant. If the power is to be distributed in the form of direct current the substations must contain switchboards, transformers, rotary converters with further switchboards ; these are expensive to install and to operate, and it is desirable to have as few distributing centres as possible. The number of such substations is therefore made as small as possible, and they are placed as great a distance apart as the distributing circuits will allow. This of course further reacts on the cost of the distributing circuits, which is very much greater than for the low tension alternating current circuits to which current is supplied from a large number of transforming points. Accumulators can obviously be used on either system ; in connection with alternate current distribution, a rotary converter charges the battery, which in its turn supplies current through the converter to the alternating circuits. A combination of the two systems may be desirable. Thus in country districts alternators supply tramways through 60-cycle rotary converters, the ordinary lighting and power work being carried out by alternate current ; the whole is supplied from one set of bus-bars, as the automatic compounding of rotary converters is such as to keep the voltage on the lighting network practically constant. W. H. S.

410. *Power Distribution by Alternate Current.* **W. S. Barstow.** (Amer. Inst. Elect. Engin., Trans. 18. pp. 827–831, Nov., 1901.)—The old system of house-to-house distribution was superseded by an attempt to inter-connect the secondaries; but it was soon found that the attempt to run transformers in parallel on the small secondary mains then existing was like paralleling compound generators through a small equalising bus-bar. Although by increasing the size of the secondary mains, the trouble was temporarily avoided, the system to-day has almost reverted to a house-to-house supply, although the transformers are arranged in groups, and are provided in case of accident with means for inter-connection. The only method of running transformers in parallel is to place each bank of transformers on a separate feeder, and to provide means for regulating the voltage on such feeders, so making it possible to divide up the load on the different transformers, and to compensate for any difference in transformer regulation. The advent of the multiphase motor has greatly contributed to the development of two- and three-phase distribution. On the biphase system, the best commercial form of distribution is by means of four conductors on the secondary side; and with the same number of conductors a saving of copper is secured by the use of three-phase current. If the secondary pressure is 110 volts, either large motors must be installed at this pressure, or step-up transformers used; in any case, the mains must be large enough to allow for the starting and stopping of such motors. The mains used are often far too small, and this has probably arisen from a mistaken interpretation of the idea that the alternating system saves copper. W. H. S.

411. *High-frequency Oscillations in High-Potential Transmission Lines.* **C. P. Steinmetz.** (Amer. Inst. Elect. Engin., Trans. 18. pp. 705–727, Oct., 1901.)—This paper contains a detailed theoretical investigation of the irregularities in the p.d. and current waves obtained at the instant of closing or opening a high-potential alternating current circuit possessing resistance, inductance, and capacity, and of the effects produced in such a circuit by the occurrence of a short-circuiting, self-interrupting arc. In dealing with a transmission line, the author assumes that the capacity is concentrated at the middle point of the line. The main conclusions arrived at are the following: (1) The most important source of destructive high-voltage phenomena in high-potential circuits containing inductance and capacity are not resonance phenomena with the wave of impressed e.m.f. or any of its harmonics, but electric oscillations produced by a change of the condition of the circuit, such as closing, opening, or short-circuiting by an arc. (2) These effects are independent of the frequency and wave-shape of the impressed e.m.f., and depend on the nature of the change which is brought about in the circuit, and on the phase of the e.m.f. at the instant at which the change takes place. (3) No dangerous rise of potential takes place in *closing* the circuit; but the oscillations set up on *opening* it when under load may become destructive if the instant of opening is in the neighbourhood of maximum value of the current. (4) If a short-circuit occurs by the formation of an arc, then at the instant of interrupting the arc the p.d. may reach values far beyond the strength of any insulation. In this case, also, the p.d. will not be excessive if the current has a small value at the instant at which the arc is interrupted.—A number of diagrams plotted by the author from the theoretical equations illustrate these results. A. H.

ELECTRICITY WORKS AND TRACTION SYSTEMS.

412. *Niagara Falls Power Transmission Plant.* **L. B. Stillwell.** (Amer. Inst. Elect. Engin., Trans. 18. pp. 541–627, Aug.–Sept., 1901.)—The paper contains an illustrated historical account of the development of the Niagara Falls Power Transmission System, with a critical discussion of the original plant and of the various modifications which have been introduced. The author adduces the history as a "demonstration of the ability of applied electrical engineering science to attain in commercial practice results predicated in large degree upon theory." The load curve for local service for the twenty-four hours ending at midnight on July 20, 1901, affords an interesting example of the high load factor that may be obtained from a large plant which supplies most of its power to factories in which the processes employed are continuous, the minimum local load during this period being 14,200 kw., and the maximum 15,700 kw. The author states that during the two years ending with June, 1901, the cost of maintenance and repairs has been less than 1 per cent. in the case of the generating plant, including alternators, exciters and switch gear; and about 2 per cent. for the motive power plant, including turbines, governors, pen-stocks, shafts, inlet racks, &c.

G. W. de T.

413. *Electric Power at Jajce.* **J. B. C. Kershaw.** (Cassier, 20. pp. 448–453, Oct., 1901.)—This station was planned and constructed by Schuckert and Co. for the utilisation of the water power available there for chemical manufacturing purposes. The water supply is drawn from a lake on the Pliva River, 129 feet above the power-house, and which has had its storage capacity increased by means of timbering to 15,000,000 cubic feet. A supply canal, about one-third of which is tunnelled and the rest open, carries the water for a distance of 3,382 yards down the river valley. Two pen-stocks lead the water from the end of the canal to the power-house. The head of water is about 110 feet, and the flow varies from 494 to 10,590 cubic feet a second, according to the season. The two pipe lines supply two rows of five turbines each, in the power-house, these turbines being of the reaction Francis type with horizontal axes. Eight of them give 1,000 h.p. each at 300 r.p.m., and drive by flexible couplings, triphase Schuckert generators in parallel. Governing is effected by a hand-controlled electrical device operated from the switchboard. The two remaining turbines develope 682 h.p. each, and are directly coupled to continuous-current Schuckert generators. Each alternator has a capacity of 3,000 amperes at 350 volts, this current being used for calcium carbide manufacture. The two continuous-current machines have a combined capacity of 7,200 amperes at 120 volts, and this current is employed for the manufacture of alkalies and chlorine.

G. W. de T.

414. *Hackney Electricity Works.* (Electrician, 48. pp. 43–44, Nov. 1, 1901.)—This article contains a brief preliminary description of the work at present done. Sufficient progress has been made to start the supply; but the work will not be completed for some time. The site of 5 acres is on the river Lea, at a considerable distance from the centre of Hackney, the longest feeder being 2¼ miles in length. The refuse destructor consists of 12 cells, which supply heat to three boilers; these are together supposed to be able to evaporate 15,000 lbs. of steam per hour, when heated with the destructor gases. There are also three Babcock boilers with superheaters, in another boiler-house on the further side of the engine-room. The chimney is 200 feet high, and has a diameter of 9 feet. The engine-room is 180 feet by 50 feet, and has a 15-ton crane. Current is supplied on the continuous-current system. The plant includes two 1,000-h.p. Bellis engines, and two 500-h.p. Willans engines, coupled respectively to 600-kw. and 300-kw. dynamos by Holmes. The switchboard is by Ferranti, the generator and feeder panels being placed back to back. The battery consists of 304 Tudor cells giving 700 amperes for four hours. Cables have already been laid in 25 miles of streets on the solid system in earthenware troughs with spigot and socket joints. Both feeders and distributors are triple concentric. Nine miles of streets will be lighted by 298 arc lamps. The price charged will be 4d. per unit for lighting and 2d. for power. W. H. S.

415. *Power Distribution in Buffalo.* **H. W. Buck.** (Amer. Inst. Elect. Engin., Trans. 18. pp. 813–819, Nov., 1901.)—This paper covers very similar ground to those noticed in Abstracts Nos. 2031, 2032, and 2290 (1901); it nevertheless contains a useful summary of the present position in Buffalo. A general map is given showing the transmission lines from Niagara to Buffalo, Tonawanda, and Lockport; also a diagram showing the connections at the Buffalo Terminal House; and another showing the 11,000-volt cable system in Buffalo, together with the position and arrangement of the circuit-breakers and section-switches. A drawing is given of the section-switches, which are used on 11,000 volts, and placed underground in vaults at convenient intervals; they are used for testing and repairing purposes, and are recommended for use on all high-tension cable systems. A list of the substations is also given, and the power supplied by each and the purpose for which it is supplied is also stated. As is well known, the Niagara pressure of 22,000 volts is reduced by transformation to 11,000 volts as soon as Buffalo is reached. The transmission line is overhead, but the distribution in Buffalo is by underground cables. It was considered that 11,000 volts was the highest safe pressure for underground work, which involved many lateral connections, frequent joints, section-switches, and switchboard connections. Higher underground pressures have indeed been used than even 22,000 volts, notably in the case of the St. Croix Power Company [see Abstract No. 716 (1901)]; but what can be done safely on a through trunk line cannot be done on a network. In the case of a short circuit practically no damage is done to the cables at 11,000 volts on account of the small current carried. Short circuits have occurred on the Buffalo cables, and it has been found that the lead was barely melted off round the fault. Inquiries have been made as to why the power is not transmitted from Niagara at 11,000 volts, and then distributed without transformation. It is stated, however, that the saving in copper on the transmission lines by the use of 22,000 volts more than pays for the transformer installation in the terminal house, and that the saving in line loss is greater than the loss introduced by the step-down transformers. W. H. S.

416. *United Railways and Electric Company of Baltimore's New Boiler Plant.* (Eng. Record, 44. pp. 419–422, Nov. 2, 1901.)—Full details with sectional views are given of the construction of the 94 feet by 181½ feet building which has been erected for the boiler plant of the United Railways and Electric Company of Baltimore, which intends to consolidate its present twelve or thirteen power stations, and house all the machinery under one roof. At present 4,000 h.p., out of a total of 16,000 h.p. ultimately wanted, have been installed, the boilers being of Babcock and Wilcox design in 500-h.p. units placed in

batteries of two. Ultimately there will be four batteries on each side, making eight on each floor, with a stack for each four batteries of 4,000 h.p. Roney stokers are used, driven by 6-h.p. Westinghouse engines with 4½ by 6-inch cylinders, each driving-shaft having an engine at each end and running the entire length of the building. In all, eight engines will be used. The boilers are constructed each of 216 4-inch tubes 18 feet long, laid 12 high and 18 wide, and two 42-inch drums 22 feet long.

Feed-water from the city mains first circulates round the bearings of the large direct-coupled engines and then passes into National heaters in which the exhaust steam from the main engines is used. From these it is conveyed to Warren-Webster open heaters, using the exhaust steam from the auxiliary engines and pumps, and reaches the boilers at a temperature of 208° F. Feed-pumps are of Blake vertical compound type with cylinders 10 and 18 inches by 10 inches.

The stacks are of steel, brick-lined, 200 feet high and 13½ feet inside diameter, with four openings for smoke-flues, two on each floor of the boiler-house. The stacks are in the centre of the building, and the boilers are placed back to back against them. Coal is raised from either rail or water by a hoisting-tower whose base spans the street railway and adjoins the quay. The tower is 188 feet high, and a duplicate will be required for the complete plant. The engine platform is 120 feet above the street level, along with the coal hopper, a crusher hopper and car being below at 102 feet. A horizontal boom 52 feet long extends over the water 146 feet above it, and buckets are raised and lowered from the boom by electrically driven winding drums. Each round trip of a bucket weighing 2,900 lbs., with its load of coal 2,200 lbs., has to be made in 72 seconds, the guaranteed performance of the whole being 50 tons per hour. As the gears transmitting turning effort to the hoisting-drums should not be subjected to shocks by sudden applications of power, acceleration is made smooth and controllable by the armature of the hoist-motor deriving its current from a generator which is motor-driven. The fields of the hoist-motor are excited direct from the feeder which supplies the motor driving the generator. A foot-operated rheostat controls the e.m.f. of the generator field. The current flowing through the armature of the hoist-motor is proportional to that e.m.f., and its torque is proportional to the controlled field strength. The buckets are lowered by gravity, brakes being used at present, but an effort is to be made to utilise the gravity force to generate electric current. An automatic railway carries the crushed coal to the main hoppers, and a bucket-conveyor takes the ashes from hoppers under the fire-boxes of the boilers, along the building, and up to an ash chute at the top, down which they fall by gravity into an ash tank placed in the hoisting-tower. They can be withdrawn from this to either cars or vessels. The original article must be consulted for the details of the building and the sectional and other illustrations which are given. F. J. R.

417. *Versailles Electric Railway.* **F. Drouin.** (Génie Civil, 39. pp. 418–419, Oct. 26, 1901.)—The line from the Invalides to Versailles, which has been equipped electrically, is supplied from the station at Moulineaux. [See Abstract No. 226 (1902).] The system of supply is three-phase current at 5,000 volts, which is converted by rotaries to continuous current at 500 volts. Of the six cables leaving the station, two go to Meudon and Viroflay, and four to a distributing box at the Pont de Passy, from which two go to the Invalides, two to the Champ-de-Mars, and one to Courcelles. The cables are constructed on the Berthoud-Borel system, in which the wire of the outer strands of each core is separately insulated; each core is paper-insulated, and the three are made up with jute worming, and the whole insulated with paper, covered with two layers of lead, and then with an armouring of two steel ribbons. The sections of each core vary from 100 to 150 sq. mm. The cables are laid at a depth of half a metre in the ballast close to the track. There are three main substations, at the Champ-de-Mars, Meudon, and Viroflay. Each contains four Thomson-Houston rotary converters of 800 kw. normal and 450 kw. maximum capacity. The pressure is regulated on the alternate-current side, by a regulating transformer with movable armature. Each rotary is supplied by a group of three transformers in triangle, reducing the pressure to 340 volts. They are ventilated by a fan driven by an induction motor. The rotaries are started by continuous current supplied from a 40-kw. generator driven by an induction motor. There are also substations for lighting and pumping at each station on the line. The line is supplied by a third rail of the same section as the track rails, and weighing 46 kilos per metre. They are supported on projecting sleepers by chairs fixed to insulators of paraffined wood, and are divided into sections of one kilometre. In laying the track an erecting car drawn by a steam locomotive was employed. This contained a 45-h.p. engine and dynamo, supplied with steam from the locomotive; the current was used for lighting and for electric drills carried on trolleys.

The electric locomotives, ten in number, are capable of drawing a load of 200 tons at a speed of 50 km. per hour up an incline of 1 per cent. Their length is 13 metres and weight complete 50 tons. Four have geared Thomson-Houston motors, and six have direct-coupled motors by Brown-Boveri and Westinghouse. The geared motors have four poles, the direct-coupled six. The ratio of reduction is 1 : 3. There are four motors on each locomotive, two on each bogie. The motors are all mounted rigidly on the truck, with a spring coupling to the axle. The armature or the gear is mounted on a hollow shaft encircling the axle; the coupling consists of six spiral springs connecting the spokes of the car wheel with a star on the end of the hollow shaft. The Westinghouse brakes are supplied by a Christiansen compresser, driven by a motor with automatic switch. A certain number of motor cars and trains on the multiple unit system are in use. G. H. B.

ELECTRIC TRACTION AND AUTOMOBILISM.[1]

418. *Modern Electric Railway Practice.* **A. H. Armstrong.** (Amer. Inst. Elect. Engin., Trans. 18. pp. 629-641, Aug.-Sept., 1901.)—Mountain railways, and high-speed passenger or freight trains which run long distances without stopping, offer, in the author's opinion, a field for the use of induction motors. In all other cases he prefers to employ continuous-current 500-volt motors, supplied through converter substations from an alternating system. Where a growing neighbourhood has to draw its supply of power for electric tram-cars from a continuous-current supply station, he advises the use of rotary converters fed from the station bus-bars, and supplying alternating current to the substations through step-up and step-down transformers. These converters may be transferred to substations when the growth has reached the point which warrants the installation of alternate-current generators. On elevated or underground railways with heavy trains and frequent stoppages, the motors must be capable of efficient acceleration with very high torque, and must not overheat to an unsafe degree from repeated temporary overloading, while the controlling apparatus must provide for their

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[1] Non-Electrical Automobiles are described in the section dealing with steam and gas engines.

efficient handling during fractional speed running. These requirements all point to the use of continuous-current motors. They can give a torque much in excess of any service demand without sacrificing their running qualities at light loads, while induction motors can meet these infrequent overload demands only by the sacrifice of some of their advantages for normal operation. Comparing the average acceleration efficiencies for the frequency of stoppages usual on American elevated railways, the author estimates them at over 70 per cent. for continuous-current series motors, with the ordinary series parallel controller, and from 40 to 45 per cent. with induction motors. In the former case the acceleration efficiency may be slightly increased by the use of a series parallel controller provided for starting with four motors in series, changing first to two in series, and then to all in multiple ; he does not, however, consider that the gain of 1 or 2 per cent. in efficiency warrants the increased complication. In the case of an infrequent service of trains, the elimination of attendance at the substations, when induction motors are used, is an important point in their favour, but, when there is a frequent service, the substations can be served by officials whose presence is required for other purposes. He suggests that track lines with heavy freight trains or high-speed passenger trains, as well as a local passenger traffic, might with advantage equip their tracks with both high-pressure overhead trolley for the operation of heavy through trains and freight work, and also use a third-rail construction to operate continuous-current 600-volt motors for the local work. He observes that both these systems could be fed from the same generator and transmission lines, operating 25-cycle rotary converters to feed the third-rail system at intervals, and step-down transformers to reduce the pressure to the 3,000 volts or more, required for the overhead high-pressure trolley line.

G. W. DE T.

419. *Electric Railway Apparatus.* **E. J. Berg.** (Amer. Inst. Elect. Engin., Trans. 18. pp. 648–670, Aug.–Sept., 1901.)—In this paper the author discusses the characteristics in American practice of the various apparatus and their limitations, which latter really decide the choice of system. *Continuous-Current Generators.*—These are usually direct driven, and of frequency varying from 6 up to 15 or 18 cycles, and in some cases as high as 25, *e.g.*, in the case of "double-current generators." In these latter the compounding on the continuous-current side is of the ordinary character, and that on the alternate-current side is by phase control, viz., the load, consisting usually of rotary converters, is made to take leading or lagging currents which react on the machine, and thereby raise or lower the voltage according to the demand.

To accomplish this satisfactorily, the armature reaction should be fairly high, which involves not too close regulation. He observes that it has been customary to ask for a regulation as close as 6 per cent., attempting no phase control, but allowing the voltage to drop slightly with the load, although the requisite armature reaction, which is usually less than that of standard continuous-current practice, is not objectionable from the continuous-current generator point of view, since the voltage is regulated by the series field. *Alternate-Current Generators.*—These are almost invariably direct driven and having a frequency of 25 cycles, unless for lighting as well as traction work. They are usually designed for a regulation of from 6 to 10 per cent. In European practice polar windings are generally used to facilitate parallel running, but the American practice is to employ machines with high armature reaction, and rely upon flywheel capacity and efficient governing.

They are always of the revolving field type, and usually installed in connection with independent flywheels. The author ascribes the general European practice of making the armature of such a great flywheel capacity as to combine the flywheel and armature in one structure, to the higher frequency employed, making the diameter of the revolving field large enough to render it available as a flywheel. Machine-wound coils in open slots are used, the sine-wave form being approximated to as nearly as possible by suitably shaping the poles and slots. Automatic compounding is restricted to the smaller sizes, large direct-driven alternators for railway work being always hand-controlled, and the fields have only one winding. *Inverted Converters.*—These are decidedly more efficient than boosters, and are coming largely into use. Their constants are essentially those of continuous-current machines working at 25 cycles. Inverted converters are larger and more expensive than straight converters, on account of the lower armature reaction requisite to close speed control and to counteract the tendency to run away in case of a load of considerable magnitude, a low power-factor being suddenly thrown on. Even so, however, speed-limiting devices should not be omitted. As the voltage must then usually drop with the load, compensation is obtained by compounding the converter proper, and inserting reactances in the leads so that the rise of voltage can be obtained across them instead of at the inverted converter. When run in parallel with alternators, their naturally uniform rate of rotation makes it necessary to give special attention to the speed regulation of the prime mover, in order to avoid cross currents. *Rotary Converters.*—Except for "hunting" troubles these would, in the author's opinion, be more usually employed in preference to motor-generators. Speed variation in the prime mover as a cause of hunting is not serious in the case of the best made engines, and turbines eliminate it entirely. Other causes are (1) high resistance between different converters on the same network; (2) sluggish magnetic circuits in the converters; (3) occasional fluctuations in the impressed voltage. To meet (1) and (2) the magnetic circuit may be largely made up of cast iron, which has a high ohmic resistance, and damping devices may be inserted, not in the path of the main flux, but midway between the poles. Case (3) may preclude the use of rotary converters when, *e.g.*, a fluctuating load is placed near the position they should occupy, and is such as would give rise to considerable periodic pulsations in the converter circuit. Matters may, however, often be improved by the use of one or more large induction motors on the circuit, or even of a small induction motor with a large flywheel. When several rotary converters are operated in the same station, it is advisable to use independent transformers, or at least transformers with independent secondaries, to obviate cross currents in case of any relative difference in the position of the continuous-current brushes on the different converters. *Motor Generators.*—With an induction motor as driver a high stability is obtained, and such a set may be employed in systems of unstable frequency and fluctuating voltage, or when many synchronous motors are in use. Otherwise the author considers that it is most economical to design the transmission system so as to allow of the use of rotary converters. *Railway Motors.*—The relative advantages of continuous- and alternating-current motors are discussed in considerable detail, and figures and curves given, *based on assumed data*, illustrating the working of a town railway line with heavy traffic on the standard continuous-current system with series parallel control of the motors, and on the three-phase induction motor system, with rheostatic control, and with concatenated control in accelerating as well as braking. The conclusions arrived at are practically identical with those in the paper considered in the preceding Abstract. G. W. DE T.

420. *Steel-Rail Specifications.* **E. F. Kenney.** (Eng. News, 46. pp. 226–227, Oct. 3, 1901.)—It is desirable to keep the percentage of phosphorus very low, but in most mills this is impossible. Where the phosphorus can be kept below 0·06 per cent., the carbon can be raised to about 0·6 per cent. without danger of brittleness. With higher phosphorus (up to 0·1 per cent., which should be the limit allowed) the carbon must be kept to about 0·45 per cent. A Bessemer steel rail containing 3 per cent. nickel, 0·5 per cent. carbon, and 0·094 phosphorus is outlasting ordinary rails on a heavy curve, and will be eventually economical. A minimum size of ingot should be specified, according to the weight of the rail, because the more work done in blooming the better. The average reduction per pass in the blooming of American mills varies from 12 to 24 per cent., and the product is much superior in the latter case. Heavy work maintains the temperature and admits of starting the ingot at a lower and therefore better temperature. The average cropping from rail steel amounts to about 5 per cent. at each end; no attempt is made to crop off the zone of greatest segregation, as is done in making axle steel. The author considers that it would be economical to insist upon greater cropping, and pay the additional cost. Test analyses are usually made on small samples cast direct from the ladle: these cool too rapidly to permit segregation, and cannot be taken as fair samples in this respect. For instance, a rail from a heat whose sample showed C 0·45, P 0·09, S 0·076, Mn 0·93 fractured, and it was found that the analysis at the point of fracture was C 0·61, P 0·20, S 0·22, Mn 1·03. Microphotographs show that a much finer structure results from colder rolling than has been usual, even if it is only the final pass that is colder. The most practical way to fix the finishing temperature is by the length allowed for shrinkage. Many rails are damaged in the straightening presses by being strained beyond the elastic limit at each blow of the gag. [The article appears to be based on the author's work as Engineer of Tests, Pennsylvania Railroad, Philadelphia.] E. H. C.-H.

421. *Trolley Lines without Rails.* **M. Schiemann.** (Elektrotechn. Zeitschr. 22. pp. 964–967, Nov. 21, 1901.)—As against £4,000 to £5,000 per km. of trolley lines on rails, including the power station, a railless trolley line costs only £1,000 to £1,250 per km., exclusive of the power station. In July, 1901, a railless service with double overhead trolley line, equipped by Siemens and Halske, was started between Königstun and Königsbrunn in the Bielathal. The 24-passenger cars resemble ordinary omnibuses, and run at 12 km. per hour. Goods vans are run at 10 km. per hour. The overhead equipment is similar to ordinary trolley lines, but simpler, no frogs or crossings being provided. When two cars meet, one lifts its trolleys off. The trolleys are on the Dickinson principle, but have special lubricated contact shoes instead of wheels, which would not allow of sufficient side motion. The cars are driven through 8 : 1 spur gearings by a motor on each back wheel. Series-parallel control is used, with short-circuited electric brake. The fore-carriage turns on rollers to facilitate steering. The route has a continuous grade of 2¼ per cent., and is full of curves, but the road surface is very good. The traction coefficient of the cars on the level road is 25 to 30 kg. per ton, *i.e.*, about double the figure for cars on rails. A railless line is essentially for light traffic, and this extra cost of operation is more than balanced by the saving in capital cost over a tramway on rails. A considerable advantage is that each factory can run out wires, and thus have goods delivered cheaply at its doors without transhipment. The results are more favourable than had been anticipated. E. H. C.-H.

422. *Rapid Transit in London.* **F. J. Sprague.** (Eng. Mag. 22. pp. 1–23, Oct., 1901.)—The author considers that rapid transit in London and its suburbs demands the widespread and radical application of electricity, with the construction of new tunnels built, according to a definite system, under the control of a single central authority, and forming a network following main arteries of traffic and connecting busy centres with each other and with outlying districts and suburban stations. The whole system should not only be constructed but worked under a single management. Classes should be abolished, one regular rate of fare established, with workmen's fares within limited hours, and there should be free exchange except on limited routes. Locomotive practice should be abolished, and trains operated in small units which could be combined at will. Electric tramways should replace many of the omnibus lines on crowded streets, and radiate from every terminus of tubular railways, and from most of the suburban stations. Every steam railway should equip at least its suburban service with electricity on a plan which permits of variable train lengths, plural control, high schedule speeds, and the maximum use of the existing permanent way. Maps are given showing existing railways and suggested additions needed to complete a harmonious comprehensive plan. G. W. DE T.

423. *Aluminothermic Process for Welding with Automatic Tapping.* **H. Goldschmidt.** (Zeitschr. Elektrochem. 7. pp. 935–943, Oct. 17, 1901.)—This is a further development of the Goldschmidt welding process [see Abstract No. 1200 (1900)]. The improvements mainly consist in the employment of a funnel-shaped crucible, having an aperture at the bottom closed by means of a small iron plate. The "thermite," a mixture of iron oxide and finely divided aluminium, is charged into this crucible, ignited, and the fused iron thus produced finds its way through the hole in the crucible into the mould surrounding the object, for instance, rails to be welded together. The operation, being thus entirely under the control of the operator, is easily performed. The tapping of the crucible may also be performed by means of a lever arrangement having a pointed iron rod for the purpose of clearing the discharge hole before pouring. The crucible, consisting of a funnel-shaped sheet-iron casing, has to be relined with a special refractory lining after from 5 to 10 "heats": a more recent improvement is the employment of a magnesia lining for the lower portion of the crucible, which part is subject to the greatest wear and tear. Ferro compounds of titanium and manganese can also be produced by mixing the respective oxides or metals. Various examples of the use the process may be put to are then given, such as, for instance, the joining of two square pieces of iron 100 by 100 mm. by means of a flange. Particular attention is drawn to the joining of steel rails, explained by a very clear drawing.

Various testimonials from railway engineers are cited, proving the excellence and strength of the welded joints. The repairing of broken propeller shafts is further mentioned, which is of very easy application, as, for instance, the work carried out by Messrs. Lester and Perkins at the Royal Albert Docks, London. O. J. S.

TELEGRAPHY AND TELEPHONY.

424. *Multiple Switchboard for the Berlin Telephone System.* **P. Krösing.** (Elektrotechn. Zeitschr. 22. pp. 909–912, Oct. 31; 928–934, Nov. 7; and pp. 947–953, Nov. 14, 1901.)—Some of the features of this board, which is by Siemens and Halske, are the following:—An exceptionally large capacity, obtained by arranging each 20 jacks in two rows of 10 each on a strip of hard rubber fixed at right angles to the longitudinal direction of the table. A reduction in the number of handles required in working the system is obtained by the introduction of call-indicating jacks, an improved form of speaking, or table, switch, and an improved ring-off indicator and polarisation cells. The call-indicating jack consists of a jack combined with a call-indicator to form one apparatus. The call-indicator, when actuated, is visible as a white pin in the shell of the jack. By introducing the hollow plug into the jack the circuit is made to the calling apparatus, and at the same time the call-indicator is returned to its position of rest. The forward motion of the call-indicating pin is produced by means of a spring released by the action of the calling current on an electromagnet arranged within the shell of the jack, the permanently magnetised core of this electromagnet holding the spring pin when in its normal position. The speaking, or table, switch requires no handle for calling and testing the connection made, since the lever, which is brought into the speaking-through position by pressing on a knob, is automatically returned to its normal position on breaking the connection. A lead weight suspended on the cord then comes into action and pulls the lever of the speaking, or table, switch into the position of rest, for which purpose the cord is connected by a chain to this lever. From the speaking-through position, by a further pressure on the knob, the switch can be brought into the hearing position, the lever, on ceasing the pressure, returning to the speaking-through position. Testing of the connections at the close of the conversation is not necessary, since the ring-off indicator in the circuit is actuated as soon as the first subscriber has replaced his receiver on the hook. This cuts out of circuit the polarisation cells, which are mounted on the speaking apparatus, which cells previously shut off the continuous current in the point connection of the plug from a ring-off indicator battery at the exchange, so that the current for the ring-off indicator is allowed to flow. Full details and drawings of all the apparatus and circuits are given. C. K. F.